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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER
CHARLOTTENLUND SLOT – DANEMARK

JOURNAL DU CONSEIL

VOL. XV · NO. 2

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR
J. R. LUMBY

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

AVRIL 1948

Notice.

The Journal of the Council appears *three times a year,* and three numbers form a volume. It includes, in addition to general articles, reviews, and bibliography, the special papers previously issued in the series of *Publications de Circonstance.*

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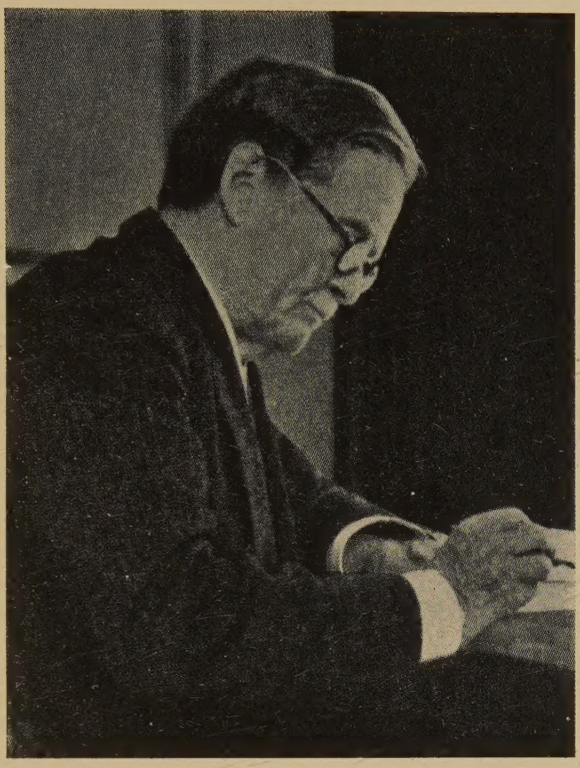
"Obituary" — Addendum.

It is regretted that the name of Dr. Bowman was inadvertently omitted from the list published in Vol. XV, No. 1 of those whose deaths occurred during the war. The following is to be added to the names of those from Great Britain (page 4).

Alexander Bowman (1876—1941): Expert, 1921—1934; Chairman, Northern North Sea Committee, 1925—34.

IMPRIMERIE A/S L. IHRICH



Otto Pettersson.

1848—1941.

OTTO PETTERSSON, chemist, physicist and oceanographer, son of a Gothenburg merchant, was born in that city on 12. February 1848, and died there on 16. January 1941. He went to the University of Uppsala and studied chemistry under L. F. Svanberg, a pupil of Berzelius, and took his Doctor's Degree in 1872, with a thesis on the selenium-alums. Two years later Svanberg retired from his chair, and Pettersson became a docent in physical chemistry; then began a close and fruitful partnership with two other

pupils of Svanberg's, L. P. Nilsson and Gustav Ekman, the latter of whom became his *fidus Achates,* his life-long friend. Along with Ekman, Pettersson made a new determination of the atomic weight of selenium, and he collaborated with Nilsson in a long series of papers, partly involving gas-analysis, but chiefly on the salts of the rarer metals, beryllium, titanium, indium, and others; another life-long friend, P. Theodor Cleve, was studying the rare earths at the same time. In 1881 a great Technical School, or Högskola, was founded in Stockholm, and Pettersson was appointed to its chair of chemistry; he held it till 1909. All the chemical work done in Uppsala and Stockholm by this little company of friends was marked by great care and accuracy, and by a firm grasp, none too common at the time, of physical methods and principles. One of Pettersson's early physical papers, on "A new principle of measuring Heat", was published in Nature (30, p. 320, 1884).

Pettersson's family had their home at Holma, in Bohuslän; and here he got his first love of the sea in the sheltered waters of the Gullmarfjord, with the Baltic at his door. His physical studies of specific heat, latent heat and heat-phenomena in general led him towards hydrography, by way of the seasonal temperatures and the ice-conditions of the Baltic and the Arctic Sea; and an early paper of his on the properties of water and ice, written in 1878, happened to attract Nordenskjöld's attention, and led to his inviting Pettersson to report on the hydrographic observations made during the Vega Expedition. His "Contribution to the Hydrography of the Siberian Sea" appeared in 1883, in the second volume of the Reports of the Expedition.

Pettersson did some of his early hydrographic work along with F. L. Ekman, a young chemist of great distinction and originality, who died prematurely in 1890. They had planned together a pioneering exploration of the coastal waters of Sweden; but it was with Gustav Ekman that the cruise was made, and a gold medal from the Swedish Academy was Pettersson's reward. The results are to be found in his "Grunddragen af Skageracks og Kattegats Hydrografi" (1891). This was the first of a long series of papers; many were written in conjunction with Gustav Ekman, and P. T. Cleve helped in others, dealing with the microscopic surface-life or plankton. Two main problems interested Otto Pettersson then and ever after. Where ocean water enters an inland sea it dips down, and lets the fresh water float out above the salt; each

layer has its own phenomena, and the submerged surface of discontinuity is the seat of waves and tides, sometimes of large amplitude. Under conditions of this kind Nansen had encountered "dead water", and Walfrid Ekman had explained that old mystery once for all; our submarine commanders were mightily perplexed by the same stratification when they first entered the Skagerak in the War of 1914—18; and here Otto Pettersson found what he called the "the Gulf-Stream water", rolling in, deep down, invisible.

The second problem, closely associated with the first, lay in the vicissitudes of the Swedish herring fishery. For Bohuslän had been the seat of the great Hanseatic herring fishery in the thirteenth and fourteenth centuries, until it came to a sudden end in the fifteenth, when the herring moved out, to the enrichment of Holland, into the North Sea. Pettersson sought to explain this great historical event, and certain other historical catastrophes such as the formation of the Zuyder Zee, as part of a long-period phenomenon, due to astronomical tide-producing conditions. At a certain rare configuration of sun and moon, he said, great under-waves rolled into the Baltic from the ocean, and brought the herring where they now no longer come; and at the same time the freshwaters were reduced to a shallow surface-layer, so apt to cool down and freeze that severe winters and a frozen Baltic were a common thing. All this work of Pettersson's is extraordinarily interesting and suggestive, but it is also complex and difficult. It is by no means conceded that the causes which Pettersson invoked are adequate to produce the results; and perhaps the time has not yet come to pronounce judgement on the hypothesis. His paper on "Climatic Variation in Historic and Prehistoric Times" (1914) contains the gist of the matter.

Pettersson's interest in oceanography was in the strictest sense scientific. All the resources of chemistry and physics were to be brought to bear on the study of the sea, and its biological phenomena were to be correlated with, and explained by, the results of the physical sciences. He taught the younger men to follow in his footsteps — Walfrid Ekman, Nils Zeilon, and his own son Hans, now the distinguished head of the Oceanographic Institute in Gothenburg. But he had at the same time an open mind to all the related practical and commercial problems. The wasteful destruction of young fish by the trawl distressed him, and he experimented on means to avoid or lessen it. He suggested new methods of life-saving at sea. But above all, and from the very

outset of his hydrographical work, Pettersson was possessed of the idea that this was work not for the narrow waters but for the open sea, and in due time for all the oceans of the world. The three Swedish pioneers, Pettersson, Gustav Ekman, and Cleve, shared their enthusiasm with Nansen in Norway, and with Martin Knudsen in Denmark. King Oscar II gave countenance and encouragement to the idea, and the first International Conference for Oceanography met in Stockholm in 1899. Svante Arrhenius was there, conspicuous among the other Swedes. Nansen was there, and John Murray, and Otto Krümmel; Victor Hensen came from Kiel and Friedrich Heincke from Helgoland; and Johan Hjort and Martin Knudsen and I who write these lines were among the younger men. It was an honour and an education to be there.

In 1901 another Meeting was held in Christiania, and there the International Council for the Exploration of the Sea came into being. The long history of the Council need not be told anew. Otto Pettersson was a beloved and honoured figure at its meetings as long as he lived. He held the Presidency during the difficult years of the first World-War, and performed the miracle of keeping the organization in being and unimpaired through it all. To him, more than any other man, its first inception was due; no man worked harder or longer for it than he did. It stands as his great and worthy monument.

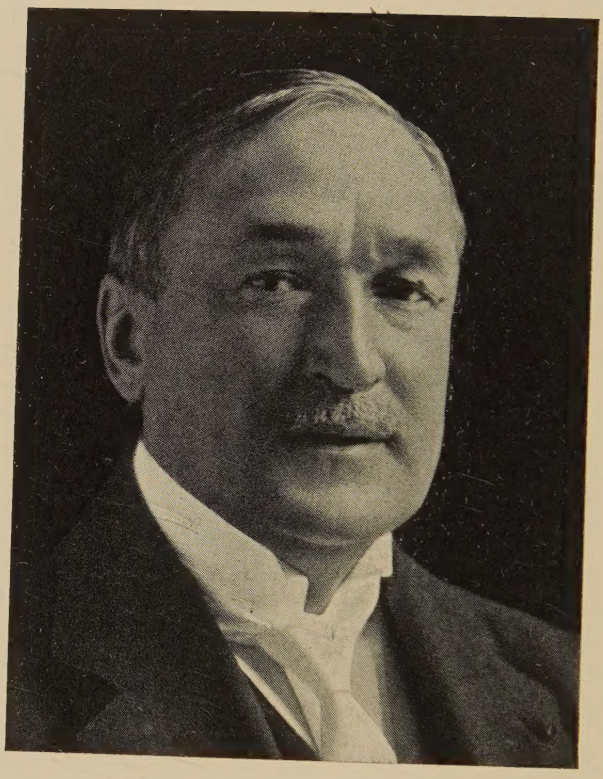
Otto Pettersson lived two happy lives, as farmer and as scientific man. "I am a peasant", he was wont to say; it was the only English word he ever mispronounced. When I once paid him a visit at Holma he had some sixty or seventy beautiful Frisian cows in his model dairy, and he had lately built his laboratory on a little rocky island just across the way. The cliff went sheer down, and the workroom actually overhung the deep waters of the Gullmarfjord. The little place was full of gadgets; water could be pumped from various depths, and all sorts of recording instruments ticked away; a copper vessel floating on the surface of discontinuity rose and fell with the submarine waves, and transmitted their motion to a recording drum. In fact, the devising of apparatus was one of Pettersson's special gifts, perhaps his greatest gift of all. The water-bottle which goes by his name and Nansen's was really his. Nansen, for all I know, may have somewhat improved it, and he used it and made it known; but it was Otto Pettersson who made it first, and gave it to Nansen to take with

him on the "Fram". Pettersson was fertile of ideas, ingenious in experiment, enthusiastic over all he took in hand to do. Age did not wither him. He kept his sturdy frame, his active mind, his warm heart, his cheerful countenance, even to extreme old age.

On his 75th birthday, in 1923, a few distinguished friends presented him with a Festschrift. Among the contributors were Johan Hjort, who reviewed the work that had been done, and what remained to do, in the study of the North Atlantic. Martin Knudsen wrote on the penetration of light in the depths of the sea; Rolf Witting on a new current-meter; van Everdingen on certain contributory causes to the formation and maintenance of a cyclone; and Hans Pettersson contributed a valuable bibliography of his Father's writings. The volume was dedicated, in all simplicity, "To a Worker of the Sea, from Friends and Fellow-workers" — "Sven Otto Pettersson, En Havets Arbetara, med Vänners och Medhjälpares Tillägnan"; and H. G. Maurice, in a foreword, paid tribute to his endearing qualities, of modesty, simple kindness, and shrewd homely wit. In the same spirit of whole-hearted appreciation Anders Ångström wrote of him after he had passed away, and spoke of his generosity of mind and gift of friendship: "Otto Pettersson var trofast i sin vänskap". V. W. Ekman wrote in like manner, in words that are not used of all men, of the spirit of the man, and of the great heart out of which it came.

Not unto everybody, not to all those whom we honour for lives well spent and work well done, do we of the scientific brotherhood pay so great a tribute of deep personal affection.

D'Arcy W. Thompson.



Théodore Tissier.

1866—1944.

LE 10 octobre 1944, M. le président Théodore Tissier mourait à Hendaye, dans cette jolie villa "Sesketan", au milieu des roseaux, qu'il avait fait construire à l'extrême pointe de la terre française, sur la Bidassoa, face à l'Espagne, et où il se plaisait à se reposer des soucis de la vie publique en contemplant les couchers de soleil sur la médiévale cité de Fontarabie. Ainsi, dans un paysage lointain, loin des rumeurs de la grande cité où il avait toujours vécu, Parisien de famille, Parisien de naissance, Parisien d'habitudes, il a terminé à 80 ans cette existence intimement mêlée aux fastes politiques de la France.

La carrière du président Théodore Tissier appartient

à l'histoire de la Troisième Republique; son indéfectible collaboration pendant plus d'un quart de siècle à l'œuvre de M. Aristide Briand l'associe étroitement à la prestigieuse figure du grand apôtre de la Paix; son rôle dans l'élaboration des textes concernant la séparation des églises et de l'État, ses interventions légales dans le statut des compagnies des chemins de fer et des cheminots mirent parfois en relief son extraordinaire habileté administrative et révélèrent au public cette figure d'un des plus grands "commis de l'État"; mais en général avec une modestie exagérée, il travaillait dans une calme obscurité, il "servait" pour "servir", faisant profiter son pays de réformes silencieuses et utiles, obtenues au prix d'un travail méthodique et acharné, et d'une ténacité toujours triomphante.

C'est à ce profond désir d'organisation, qui était l'essence même de son caractère, que l'on doit son intervention magistrale dans la création et le développement de l'Office Scientifique et Technique des Pêches Maritimes. Avec une souriante bonhomie, il se plaisait à raconter comment il avait été amené en 1919 à accepter la présidence du Conseil d'administration de ce nouvel établissement d'État: "Ce Conseil, disait-il, était formé de professionnels des industries de la pêche, armateurs, pêcheurs, ostréiculteurs et de savants; or, savants et professionnels ne pouvaient s'entendre sur la direction à donner à l'Office; il fallait les mettre d'accord et l'on vint s'adresser à moi, parce que n'étant ni savant ni professionnel des industries de la pêche, j'étais parfaitement incompétent et de ce fait absolument impartial". En dépit de cette agréable boutade, M. le président Théodore Tissier avait su, quelques semaines après sa prise de fonction, faire un choix judicieux dans les questions essentielles qui devaient être retenues pour assurer l'essor de la pêche française, renaissant avec peine des difficultés de la grande guerre.

De 1919 à 1944, pendant vingt-cinq ans, il a bien voulu conserver ce rôle de pilote pour guider l'Office, s'intéressant dans les moindres détails à sa vie et à sa constitution, contribuant sans cesse à son constant développement, lui faisant surmonter toutes les difficultés si nombreuses qui jalonnèrent sa route, surtout pendant les premières années, critiques des professionnels, méfiance des pouvoirs publics, insuffisance budgétaire. Sous sa puissante impulsion, les obstacles s'aplanissaient et chaque fois l'institution sortait de la lutte confirmée et agrandie. Malgré les lourdes préoccupations que lui imposaient ses hautes fonctions, soit comme Président de la section des Travaux publics au Conseil d'État, soit comme Vice-président de ce Conseil,

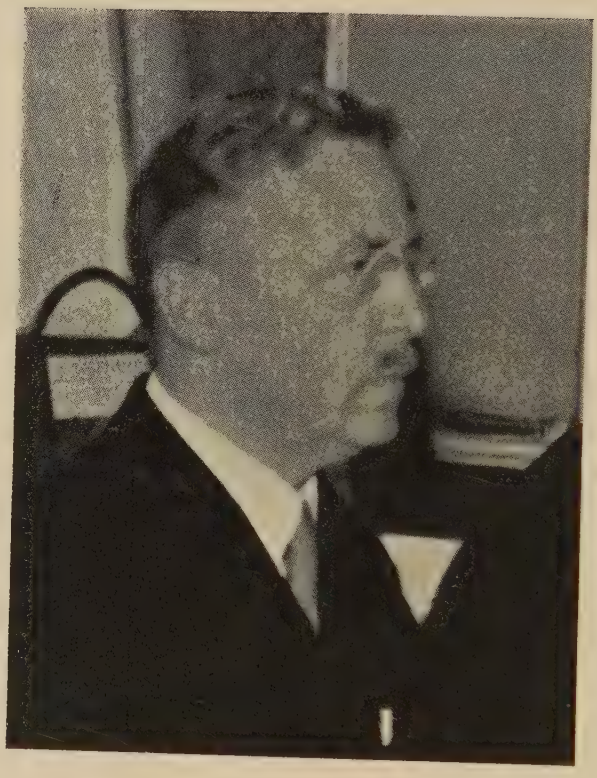
soit comme Secrétaire d'État aux Affaires étrangères, jamais il ne regarda comme négligeable et de second ordre ce qui touchait à l'Office des Pêches maritimes et je me rappelle avec une fervente reconnaissance les conseils qu'il voulut bien me donner alors que j'étais jeune directeur, me faisant profiter avec une surprenante clarté de sa légendaire expérience administrative.

L'œuvre technique et scientifique de l'Office l'intéressaient à un haut degré : il comprit parmi les premiers l'utilité du contrôle sanitaire des huîtres et coquillages et prit une part des plus actives dans l'élaboration des textes réglementaires qui sanctionnèrent ce contrôle; de même il réalisa l'importance de l'application des procédés frigorifiques au commerce de la marée; enfin il suivait avec un très grand intérêt toutes les recherches d'océanographie et de biologie marine : avec une précision remarquable, il savait poser les questions essentielles qui lui permettaient d'apprécier la valeur d'une théorie ou l'utilité de certaines études.

Mais c'est sur le plan international que porta surtout l'effort de M. le président Théodore Tissier : il se plut dans ces réunions de techniciens et de savants qui discutaient des grands problèmes de l'économie marine, de l'exploitation rationnelle de la mer, de la protection des fonds de pêche; il fut séduit par le caractère pacifique de ces assemblées et considérant que la France ne saurait être écartée de toute œuvre de paix, il s'attacha à lui donner la place importante qui lui revenait dans ces grands organismes internationaux. Depuis 1920 il remplissait les fonctions de Vice-président du Conseil international pour l'exploration de la mer, et les présidents successifs de cette haute institution, M. H. G. Maurice, Secrétaire des Pêcheries d'Angleterre et l'illustre biologiste Johan Hjort, de Norvège furent ses intimes amis : tous deux avaient fréquemment recours à sa haute capacité juridique pour mener à bien les affaires du Conseil. De même, M. le président Théodore Tissier assuma la présidence de la délégation française à la Commission internationale pour l'exploration scientifique de la Mer Méditerranée, et contribua fortement à l'élaboration des statuts de cette commission. Il savait trouver le temps nécessaire pour assister aux réunions de ces institutions; chaque année, il se rendait à Copenhague; il avait acquis une réelle popularité, nombreux étaient les inconnus qui le saluaient quand il traversait les rues de cette belle ville; et Sa Majesté le roi Christian X lui remit le grand cordon de l'Ordre du Danebrog, pour le remercier d'avoir aidé à maintenir dans sa capitale le siège du Conseil international.

C'est pour que la France garde une place de premier ordre au milieu des nations intéressées aux sciences de la mer que M. le président Théodore Tissier mit tout en œuvre pour que notre Pays soit doté d'un bateau de recherches muni de l'outillage le plus moderne et le plus perfectionné : ses efforts aboutirent à la construction de ce remarquable navire auquel son nom a été attaché, en témoignage de reconnaissance. De 1934 à 1940, sous notre pavillon, le "Président Théodore Tissier" a parcouru l'Atlantique de Terre-Neuve jusqu'à la côte d'Afrique équatoriale; les résultats de ces croisières sont connus du monde scientifique et ainsi se trouvera conservé parmi les savants de tous les pays, le nom de celui qui contribua si largement au développement de l'océanographie française.

Ed. le Danois.



Carl Heinrici.

1874—1944

IN 1935 an American, Hans Zinsser, published a book in which he said that international co-operation continues peacefully no matter how hostile and warlike life is. All kinds of medical officers, bacteriologists and sanitary inspectors co-operate; they consult each other for advice, freely exchange ideas, scientific material and methods. Dr. Heinrici's many years of active work in the International Council for the Investigation of the Sea are further proof of the independence of international co-operation of all national disputes.

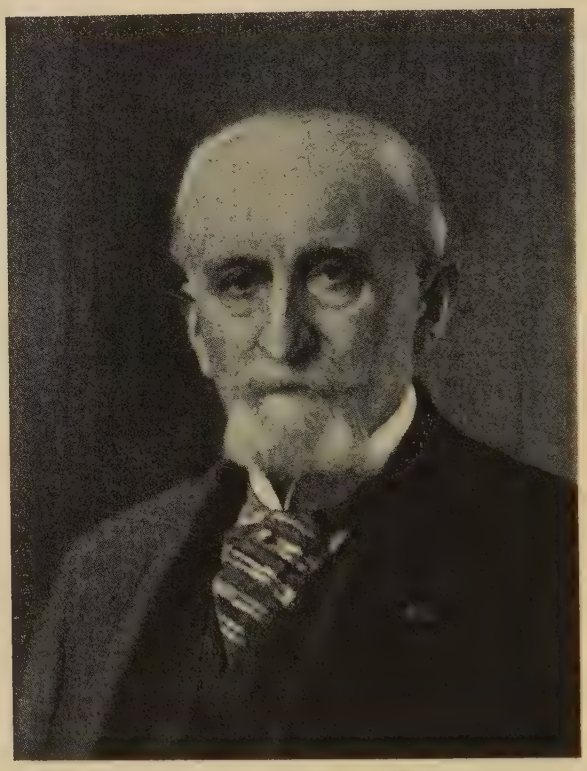
In 1925 he was charged with the task of reorganizing the marine investigations of Germany. He succeeded in restoring the great journal "Berichte", which has since then appeared in 10 volumes containing 141 papers on the investigations conducted by German scientists in the Baltic, the North Sea and the Barents Sea.

When Germany again began to take part in the work of the International Council in 1926, Dr. H e i n r i c i became her delegate, and in 1927 he was elected Vice-President, or member of the Bureau. In this post he worked for international cooperation, both in the years of peace and of war, with the greatest energy.

In 1939 he succeeded in organizing a meeting in Berlin at which the greatest hospitality was shown and representatives of all countries were given an opportunity of getting to know the work of German science.

During the war he took part in the work that had to be taken over by those members of the Bureau who were still able to meet. He succeeded in obtaining not only the ordinary but also the extraordinary contributions to the Council's budget from Germany. This active work of his was of the greatest importance in steering the Institution safely through the war. It enabled the delegates of those countries who had been cut off from the international work during the war to begin afresh with the Institution they had created before the war, and with such considerable funds at their disposal as to cover expenditure even in the years when it exceeded income.

Johan Hjort.



Gustave Gilson.

1859—1944.

THE part which Belgium has played in the activities of the International Council for the Exploration of the Sea has, from the very beginning, largely depended on Gilson's personal influence.

Gilson began his scientific career as a cytologist; he underwent his original training in J. B. Carnoy's laboratory at the University of Louvain. For more than half a century he was Professor of Comparative Anatomy and Embryology at this University, where he succeeded P. J. van Beneden. During his long career, entirely devoted to pure science, he

influenced the development of biology in his own country in many ways.

After a voyage of exploration which brought him to the Fiji Islands in 1897, he started the investigations of the Belgian sea coast which were included in the programme of the Royal Museum of Natural History in Brussels. The directorship of this Institution gave him an opportunity to organize the exhibition of the collections, more especially of the Crustacea, according to his own very progressive conceptions. His remarkable views on the rôle of a museum as an organization for scientific research are embodied in his "Musée d'Histoire Naturelle Moderne" (1914).

Gilson's initiative was also largely responsible for the Belgian investigations of the central African Lakes.

In spite of his absorption in administrative work, cytology remained one of Gilson's most profound interests. He and his pupils published many papers on the finer structure of the Arthropods. Cytological technique owes him more than one improvement; he introduced fixing and mounting media which proved of permanent value. As a co-editor of "La Cellule" he kept contact with the rapid expansion of this branch of biology and in the later years of his life he resumed this side of his work.

His studies on the biology of fishes and Crustacea brought him into contact with commercial fishery problems. His long-range plans were, however, not always properly understood by the fishermen whose main desire was for immediate results, whence arose many of those difficulties which so greatly hampered Gilson's work on the biology of marine animals.

The first world-war badly interrupted his researches on the bottom fauna of the Belgian coastal waters, and the major part of the work remains unpublished.

Over many years he concentrated his attention on the biology of the spent herring shoals appearing annually on the Belgian coast. A large amount of his time was also devoted to the study of the effect of the destruction of small fish; the results of this work appeared for the most part in the "Annales de l'Institut de Recherches Maritimes d'Ostende" a publication which Gilson initiated.

The transformation of the small institute in Ostend, which lacked so many of the essential facilities for research, into a modern well-equipped building absorbed a large part of Gilson's never-failing energy.

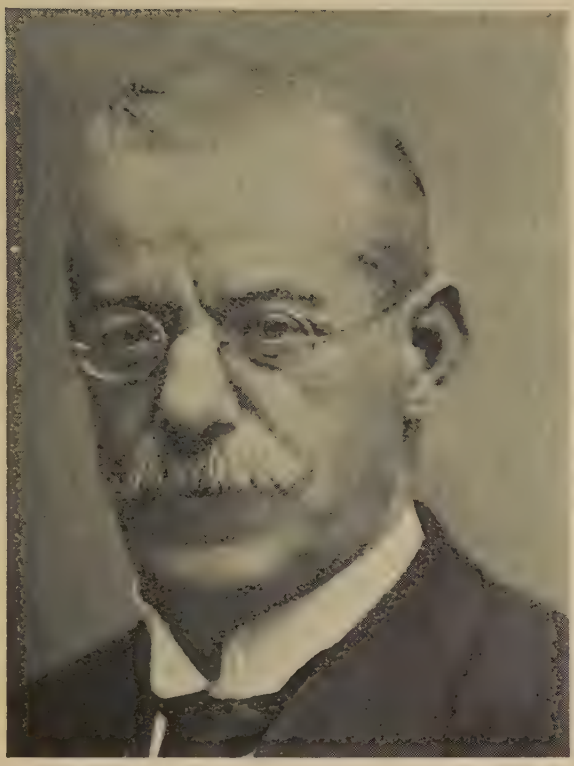
During the second world-war the institute had to be evacuated and Gilson felt it very deeply that he was unable to

continue his work. He died, fortunately for him, before learning of the final destruction of his cherished institute.

During his long career, which ended at the age of 86, G i l s o n' s teaching and communicative enthusiasm strongly impressed many generations of students: those who had the privilege, as I had, of attending his lectures keep a vivid memory of his clear, synthetic mind.

G i l s o n' s charming personality brought him many friends, among the younger as well as the older, biologists of his country: they will resume the effort to create the Belgian Institute for the Exploration of the Sea, which was G i l s o n' s dream.

H. J. Koch.



Odon de Buen y Del Cos.

1863—1945.

AS a young man, Professor Odon de Buen y del Cos studied Natural Sciences in the Universities of Zaragoza and Madrid, with such success that he won the Extraordinary Prize at the end of his studies. In 1885 the Spanish Government commissioned him to undertake scientific investigations during the cruise made by the frigate "Blanca". From 1889 he held the chair of Zoology in the University of Barcelona and later in Madrid.

His predilection for the study of Marine Biology led him to found the Marine Biological Laboratory of the Balearic Islands in 1906, in Palma de Mallorca. In 1908 he was appointed Honorary President of the "Société Zoologique de France" and a life member of its Board. A great advocate of experimental methods in the study of natural sciences, he popularized them in lectures, publications, and frequent excursions, and endeavoured to convert his professorship into a kind of experimental laboratory. He managed to arouse and encourage in Spain an interest in the study of Marine Biology and Oceanography and soon became an outstanding figure in the scientific world. In 1914 he founded the "Instituto Español de Oceanografía", the only scientific centre devoted to studies of this kind in Spain, and was the first President of the Institute. In his long professional career he published numerous works on marine science and the industries connected therewith. These works were published by the "Instituto de Oceanografía" and in a large number of Spanish and foreign periodicals. He made many oceanographical expeditions in collaboration with Prince Albert I of Monaco and professors of the French Laboratory at Arago, in the Spanish warships "Vasco Núñez de Balboa", "Hernan Cortés", "Río de la Plata", "Marqués de la Victoria", "Eduardo Dato", "Xauen", "Giralda", "Almirante Lobo", and the small sailing vessel "Averroes".

From 19th July 1924, when Spain joined the International Council for the Exploration of the Sea, he was the first Delegate for Spain, and was present at all the annual meetings, in which he played an important rôle; he presented interesting papers on the biology of Spanish waters and supported all the undertakings of the Council.

As Delegate for Spain, he also belonged to the International Commission for the Scientific Exploration of the Mediterranean, of which he was Vice-Precident, and here he carried out work similar to that which he did in the International Council for the Exploration of the Sea and the Section of Oceanography of the International Geodetic and Geophysical Union. It may be affirmed that he was the master of all the marine biologists of Spain and that his teaching and lectures have greatly favoured the development of Oceanography in Spain.

He died on 3rd May 1945.

Rafael Garcia Rodriguez.

Rolf Johan Witting.
1879—1944.

ROLF WITTING, a native of Wiborg, matriculated from the local Swedish Lyceum. In 1901, after having studied at the University of Helsingfors for four years only, he obtained his B. A. degree with the highest honours in mathematics, astronomy, and physics. In 1909 he passed his final examination and graduated Ph. D. in 1910.

He died suddenly from heart-stroke and it is very probable that his last year's activity in public life, where he occupied a responsible and very strenuous post under exceptional circumstances, caused his strength to ebb prematurely.

W i t t i n g' s scientific activity began while he studied for his B. A. examination, for he then acted as assistant at the Helsingfors Astronomic Observatory for close on two years. The extraordinarily good training obtained by him during this

period under the Direction of Anders Donner, professor in astronomy, was highly appreciated by him.

It was Donner who drew the attention of the Finnish Scientific Society to the young and talented Witting, when they were looking for a suitable physical assistant for Professor Th. Homén, the leader of the Hydrographic-Biological Commission founded by the Society in 1898. On 1st May 1902, Witting was appointed to this post.

Homén remained in name the leader until 1911, but his many other offices and especially his activities as a politician — indeed, politics seem to have an aptitude for engulfing everything and everybody — hindered him from partaking to any noteworthy extent in the hydrographical research work to which Finland had been linked on his own initiative. Witting was the actual leader from the very beginning.

Witting's first practical goal was to fix the working programme for thalassological research in Finland. He succeeded in developing the organization by degrees until the goal was reached in 1918, when a Government "Thalassological Institute" was founded. Its Finnish name is "Merentutkimuslaitos", and the Swedish, "Havsforskningsinstitutet". The Institute worked, and is still working, in three departments, all of which have a physical and chemical working programme. Witting always insisted that biological research be separated from the physico-chemical side. Witting became as a matter of course the chief of the Institute with the title of professor. He nominally occupied this post until 1936 when he resigned and became the Chief General Manager of one of Finland's leading commercial banks. Actually, due to his political activity, he had taken no part in the Institute's work after 1933, and only sporadically and with long interruptions since 1924.

At the meetings of the International Council for the Exploration of the Sea, Homén represented Finland until 1907. Thereafter Witting was Finland's representative, his last meeting being the 25th in 1932. As proof of the esteem that Witting enjoyed among his colleagues must be considered the fact that he was elected as secretary-general of l'Association Internationale d'Océanographie in 1930, from which post he resigned in 1933.

One of the leading principles of Witting's thalassological work, which has left its mark on the work of the International Council for the Exploration of the Sea, was that the Baltic could be considered as being to a certain extent a "laboratory sea", the study of which enabled one to grasp the hydro-

graphic occurrences in more extensive sea areas. He himself often followed this principle in his investigations and it cannot be denied that several hydrographic problems of general interest have obtained their first satisfactory treatment just within the Baltic area.

Among the ideas, based upon this principle, that Witting put forward at the meetings of the Council can be considered his suggestion for an international investigation of the currents and of the changes of water in the transition area lying between the North Sea and the Baltic. This resulted in a joint expedition of five research vessels from Denmark, Finland, Germany, and Sweden to the Cattegat in the summer of 1931. Witting was the leader of the Finnish group, whose programme included, *inter alia*, extensive measurements of currents with the aid of an electrically recording current meter constructed by himself.

The current-measuring problem was one of the first to interest him; his current meter had been in his mind ever since his first introduction to thalassology, and he improved the model from time to time. Another instrument for the need of which he became aware in connexion with the net of stationary hydrographic stations along the coast of Finland, and which he made up his mind to build, was a small, easily managed deep-water sampler. The problem was solved by him, and after a number of models had been tested a sampler was constructed that functions without springs and, after having been in use for more than three decades, has shown itself to fulfil his expectations in a most excellent manner.

Another goal that Witting, as chief of the Thalassological Institute, had determined to attain was the establishment of a net of self-registering mareographs along the coast of Finland. In collaboration with Dr. H. Renqvist, chief of the Water Level Department of the Institute, Witting constructed for these stations a self-registering mareograph of quite a new type, the principal characteristic of which is that it reproduces the water-level changes in their natural scale.

Another branch of the Institute's activity that commenced during World War I, i. e., the ice service, and which soon became the centre point of the Institute's practical work, needed less instrumental equipment but more specially prepared maps and journals.

As already mentioned, investigations of current conditions take an important position among Witting's first hydrographic tasks; among other things, he investigated the relation between winds and currents and demonstrated, being one of

the first to do so, the turning of the so-called drift-current to the right of the direction of the wind. He also established the quantitative relation between the speed of wind and current within limited seas areas. Current conditions formed an important section of his first large scientific work, which dealt with the movements of water and the water changes in the Gulf of Bothnia (1908). His account of the sea in the Atlas of Finland (1911) can be considered as being an extension of this work to cover the whole of the North Baltic.

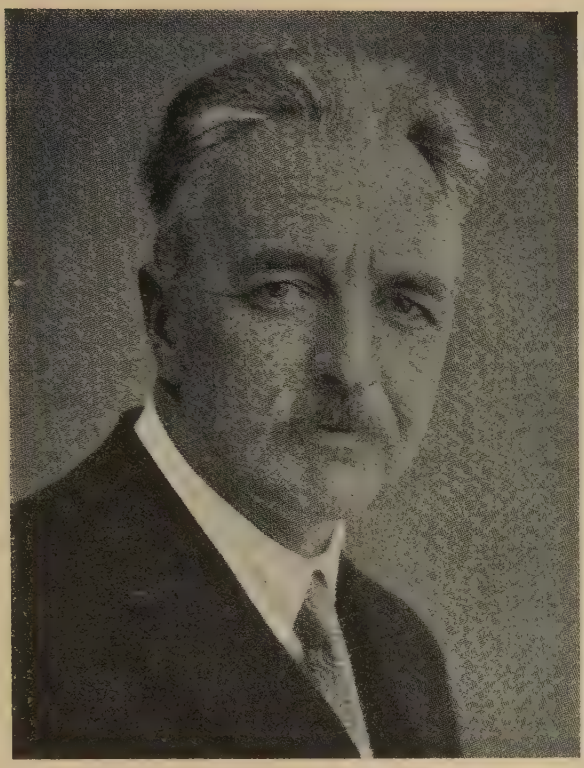
In 1911 Witting published an exhaustive investigation of the tidal waters in the whole of the Baltic, which work became the basis of a mathematical theory for free and compelled oscillations within a limited sea area. Witting planned to continue the investigation later on with the aid of more complete data.

For Witting World War I was a period of intense scientific activity. From this came his work on the water surface, the geoid surface, and the rising of the ground along the Baltic (1918). Here he also demonstrated the accuracy of the so-called thalassological levelling and even succeeded in carrying out an exact treatment of the rising ground phenomenon, so important to the whole of the North. Witting reverted to the same problem in an investigation made in 1943, when he was still busily engaged in other activities.

In 1944 Witting again occupied a post at the Thalassological Institute, and shortly before his death he had completed an investigation into the light conditions prevailing in the sea. In this investigation he used the data that had remained unutilized when his energy had been taken up by activities other than science. Some hours before his death he expressed to his wife his joy in being able to occupy himself again with scientific work. The investigation of light just mentioned shows how desirable it would have been for Witting to be able to complete the work begun by him. It is still uncertain to what extent others can continue it with the aid of the papers that he left behind him.

As an individual Witting was markedly an extrovert. With his lively imagination and his rich stock of knowledge he became a popular and in some respects even a fascinating social person who liked to treat both serious and humorous subjects in a light conversational tone, sometimes mixed with a touch of sarcasm. With his strongly pronounced individualism he made a lasting impression on all who met him.

Gunnar Granqvist.



H. C. Redeke.

1873—1945.

IN APRIL 1945, a few weeks before our final deliverance from the oppressing German yoke, Dr. H. C. Redeke, late Director of the State Institute for Biological Fishery Research, died at Utrecht of a chronic illness. With him, the oldest fishery biologist of our country passed away.

Born in Amsterdam on 29th August 1873, Redeke graduated at the University of that town in 1898. Even before that, he participated in fishery investigations at the Zoological Station of Den Helder, under the leadership of Dr. P. P. C. Hoek. After the latter had settled in Copenhagen as the first General Secretary of the Council (1902) Redeke was charged with the organization of sea fishery research, particularly in

connexion with the programme of the recently established International Council for the Exploration of the Sea.

In the opening years of the present century all scientific study, as well as the administration, concerned in this field of exploration, was still in its infancy and in a fluid stage, so to speak; it had to be real pioneer work. So, both H o e k and R e d e k e had it all their own way, of course within the limits of Governmental financial aid. R e d e k e took up his task enthusiastically in a hitherto hardly explored field. First as expert, later (1916) as one of the Delegates for the Netherlands in the Council, R e d e k e took an active part, so far as the means available allowed, in working out the programmes of the various committees of which he was a member (in 1912 and 1920—22 he was chairman of the Plaice Committee and in 1920 of the Limnological Committee) and a major achievement was his contribution to our knowledge of the propagation of food fishes in the southern North Sea and a more satisfactory method of collecting Dutch fisheries statistics. He also studied the many-sided methods of fishing in the Zuiderzee and drew up valuable reports on fish, fishing gear and vessels, and destructive methods of fishing in these waters. He acted as Scientific Adviser to the Government on fishery matters. When Dr. H o e k returned from Copenhagen in 1907 and resumed his former office, R e d e k e remained in charge of the sea fisheries, and eventually succeeded H o e k after the latter's death in 1914. During the first World War all sea investigation had necessarily to be suspended, and R e d e k e began instead an exploration of our freshwater fisheries, for which he had the use of a barge "Meerval" with which, in the course of time, he visited most of our provinces. This field of research, as well as that of the Zuiderzee (afterwards Yselmeer), held his keen interest to the last. He organized courses for students in limnology; he delivered clear and fascinating lectures for fishermen in various harbours; and in 1916 he was appointed a lector at the Amsterdam University on hydrobiology and planktology.

The application of pure science to practical questions regarding fisheries had a great attraction for him.

The problems of the post-war period in the 'twenties brought to the foreground many points of a technical and economic nature, and the need of improvements in our sea fisheries, which had, on the whole, lagged behind those of other North Sea nations. R e d e k e tried hard to assert himself as an expert in these matters also, against others who claimed to possess a better insight into practical matters, but it is not necessary to

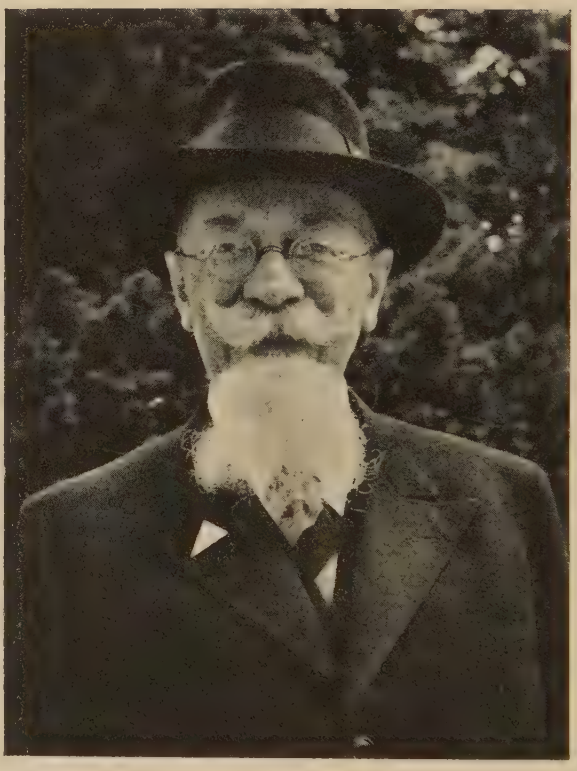
deal here with these conflicts. R e d e k e devoted himself more and more to limnological subjects, to the fauna of brackish waters, to diseases of fish, and the organization and maintenance of our salmon fisheries; he wrote faunistic papers on the fish occurring in the Netherlands, and he contributed or edited two extensive reports on the faunistic changes consequent on the draining of the Zuiderzee. On the occasion of his 70th birthday, when he had already lived for a number of years at Utrecht, his work was given its due appreciation by various people, including a host of young students who, as a result of R e d e k e' s unflagging activity in the Hydrobiological Club (of which he was the founder in 1921), felt the desire to honour him. He was at that time fully engaged in the preparation of a comprehensive work on the Hydrobiology of the Netherlands, which death has unfortunately prevented him from completing.

R e d e k e was a kind man, generous, quick to appreciate, and gifted with a sense of humour which he vented occasionally in bon-mots. Dominant in him was an artistic strain, coupled with good taste. He was fond of music, and well versed in literature. His outstanding trait was his desire for neatness. Not only was his laboratory always neatly arranged, but he never allowed himself to be slovenly in his dress. His editorial gifts were obvious from the judicious arrangement of the more voluminous reports that he wrote or edited. His love for books, not to say his piety, stood him in good stead in the cataloguing of the libraries of the Zoological Station and, long afterwards, of Utrecht University. His useful work as Director of the Zoological Station at Den Helder from 1902—1929 was gratefully acknowledged by his appointment as an Honorary Member of the Netherlands Zoological Society.

The older members of the International Council will no doubt remember R e d e k e' s forceful personality, his eloquence and his ableness in conducting an argument in foreign languages; and in personal intercourse, they will recall his cultured mind.

The list of his publications, dating from 1896 to 1943, for a large part in national periodicals, but also, up to 1939, in the Journ. du Conseil, in the earlier volumes of the Rapp. et Proc.-Verb., in the Fauna of North Sea and Baltic, the Rev. Internat. de Hydrobiol. et Hydrogr., etc., numbers 265 papers. His sense of neatness induced him to date all his papers carefully when finished, so that it was possible to arrange them all chronologically in the catalogue published in Vol. VII, 1943, of the Arch. Néerl. d. Zool., on the occasion of his 70th birthday.

J. J. Tesch.



Michal Siedlecki.

1873—1940.

MICHAL SIEDLECKI was born in 1873 at Cracow, with which famous city he was associated during the greater part of his life, taking his doctor's degree at its University in 1895, and returning to it as lecturer in 1900, after some years spent in research in Berlin, the Pasteur Institute in Paris, and the Zoological Station at Naples. In 1912 he became Professor of Zoology and Director of the Zoological Laboratory and Museum, a post which he held to the end of his life.

Like the late Professor G. Gilson, Siedlecki had become a very distinguished figure in general zoology before he became interested in fishery investigations. When a young man he carried out some classical researches on the Sporozoa, at first in collaboration with Fritz Schaudinn, the famous protozoologist, and later independently. Siedlecki's pioneer contributions to protozoology have been reviewed by Dr. Clifford Dobell in a masterly manner in an obituary notice to which I owe much (Parasitology, XXXIII, pp. 1—7, 1941), and from which I quote the following — "Just as Schaudinn and Siedlecki together produced order out of chaos in our knowledge of the Coccidia, so Siedlecki alone clarified, at a stroke, the muddled conceptions then prevailing about the development of the Gregarines." And again — "Of Siedlecki's contribution it may be justly said that his work has now so completely permeated the *corpus* of modern protozoological knowledge that its origin is almost forgotten and its correctness is no longer questioned. This is surely the hallmark of fundamental scientific research."

His zoological researches were not limited to the Sporozoa, but covered a wide field. He became much interested in tropical wild life during an expedition to Java in 1908—09, and made a special study of the biology of the flying frog *Rhacophorus*. Nor was he only a zoologist. From my conversations with him I gathered that he played a considerable part in the reconstruction of the new Polish State after the war of 1914—18, especially in connexion with education, and Dobell records that he was Rector of the University of Wilna for two years during that reconstruction period. In his later years he had much to do with the preservation of the fauna of Poland, includings its European bisons, and the formation of Nature Reserves, and he took an active interest in the International Committee for Bird Preservation.

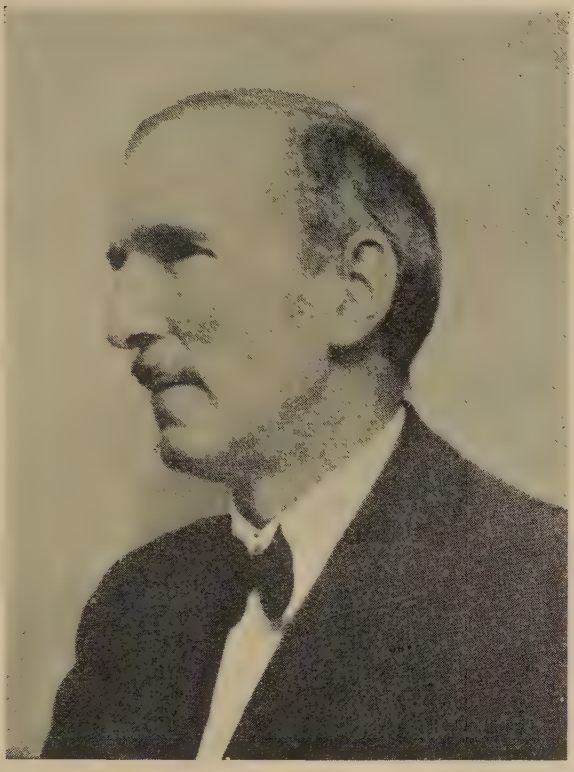
His association with the International Council dates from 1924 when he attended the annual meeting as a visitor. In 1925 he became a Delegate for Poland and remained so to the end. He was elected chairman of the Salmon and Trout Committee in 1931, and guided its deliberations — originally devoted largely to the salmon of the Baltic — with skill and dignity up to the Berlin Meeting in 1939. He was also an active member of the Baltic Committee. He published a few short papers in the Council's Proceedings, his last being an interesting note on Fish Migrations, calling for further investigations, which appeared in Rapp. et Proc.-Verb. 109 (1), p. 31, 1939.

He did a great deal for Polish fisheries and fishery research and helped to establish the marine biological station at Gdynia. To stimulate popular interest in marine biology and fisheries he published in 1923 a small well-illustrated book, "Skarby Wod", or The Treasures of the Waters, and a second edition appeared in 1928.

The gentle charm of Siedlecki's personality was irresistible. His wide culture, embracing world literature, art, and philosophy as well as science, his aristocratic courtesy, and his ever present sense of humour, made him a delightful companion. I remember many happy evenings spent with him over a glass of beer, talking of this and that, and particularly our last meetings in the spring of 1939 in Berlin, where we made a pilgrimage to the Museum to see the head of Nefertiti for which he had a great affection, and to the Zoo, where on the last occasion we sat and listened to the howling of the wolves. One remembers too those artistic gems, original sketches or beautiful photographs of Polish country, which used to arrive at Christmas time. Many of his colleagues in the Council will remember with poignant feelings that last delightful speech he made after dinner at Hamburg, unthinking of the gathering clouds of war.

His end was tragic, and moved his many friends to horror and indignation. He was arrested by the Germans in November 1939 together with all the other professors of Cracow University and sent to the infamous concentration camp of Oranienburg, where he died in January 1940, being unable, as his friend and colleague Dr. Lubecki wrote me, to "support the sadistic atrocity of the German treatment".

E. S. Russell.



Oscar Sund.

1883—1943.

OSCAR SUND was one of those who gave their lives in the last Great War. Returning from investigations in northern Norway he had almost reached home when, in October 1943, his ship fell a victim to war operations. While the burning ship was being driven on to the rocks, he calmly advised fellow passengers who were about to jump overboard, "Stay put; we are still afloat". At last he also had to jump into the breakers beating against the burning wreck in the gathering twilight, and the sea took him to its bosom — the same sea to which he had dedicated his life work, and which had borne him for so

many years, in storm and calm, asking him questions which he had tried to answer and answering questions which he had asked.

S u n d' s scientific production was not voluminous, and as he did not write any complete work about what had particularly occupied his time, it is difficult to review his work in all the various spheres in which he was interested, but it may be stated that his products reflect his versatility and his foresight.

S u n d' s chief professional work was a study of the biology of the sprat, for which he used material gathered on many different expeditions, but his principal interest lay in the cod investigations, to which he has made lasting contributions.

The principal factors in the biology of the "Skrei" and the "Loddetorsk", and the importance which the renewal of the stock played for later catches were made clear by the investigations of G. O. S a r s, Johan H j o r t, and D a m a s. We owe to S u n d' s years of study and his clarity of expression the picture we now have of the recruitment of the stock and its course.

World War I produced stagnation in public and official interest in marine biological investigations, and this resulted *inter alia* in the reduction of scientific staffs. Consequently it was of tremendous importance that Norwegian fishery research should have had a man with S u n d' s ability and versatility. Besides his thorough grasp of his own particular subject S u n d possessed such extensive knowledge in hydrography, chemistry, and mathematics that here also he could make valuable contributions.

The work on board the small research vessel, the "Johan Hjort" — what with limited space and limited help, but with unlimited tasks — moved S u n d to invent time- and labour-saving methods.

In 1928 he undertook research on the phosphate and nitrate contents of sea water. While formerly the rivers had been considered the main source of these salts, S u n d was able to show that it was the deeper layers of the sea that contained the fertilizer reserve, and that convection currents carried these up to the life-giving light of the upper layers.

S u n d' s common sense was always alert where technical progress was concerned. Thus the honour is due to him for having introduced the echo-sounder to the service of the Norwegian fisheries, and the ability to determine the exact location of the schools of fish has been of great importance in exploiting the fisheries.

Where, also, new fishing gear was concerned he had something to say. He constructed a sink-purse-seine for "Skrei"-fishing, based on new combinations of well-tried principles.

There are numbers of innovations which originated with S u n d. Hardly known, and not yet in print, is his catalogue of Norwegian coastal names. In this he has tabulated 12,000 names of fjords and sounds, coves and voes, bays and portions of the open sea, islands, holms and skerries, peninsulas and nazes, points and isthmuses, beaches and promontories. This catalogue sprang from S u n d' s geographical interests. Nobody was more enthusiastic over a good map, and nobody more annoyed with a bad one. Behind it all was his love of his country and his determination to better the living conditions of its people.

It was quite natural that northern Norway should engage his special attention. Not only was he a native of it, but his sympathies lay there because northern Norway must fight for the advantages which other parts of the country have had given to them.

To S u n d it was evident that communications should be made easy, and he therefore fought to get roads built wherever the mountains were a hindrance and to increase the accommodation for shipping where the sea was the only solution.

In this connexion may be mentioned his small but interesting pamphlet on density of population, printed in *Nytt Geografisk Tidsskrift*, in which he proposed a new definition of the principle of density of population. S u n d pointed out the contradiction in fixing the population of a community in relation to the area, which might be either naked mountain or bog, lake or woods. He proposed instead to define it in relation to the shortest routes connecting all inhabited places.

One of S u n d' s larger works is his contribution to "Die Norwegische Seefischerei" in *Handbuch der Seefischerei.* This is a summary account of the Norwegian fisheries — their history, technique, and natural conditions. Of particular interest is the graphic form in which S u n d presented statistical information. All the way through he stressed the necessity for the illustration to answer its purpose. Just like an artist, who works to a particular design, so S u n d always tried to make his graphic illustrations easily understood. In this respect, as in so many others, he was a pioneer.

In the International Council S u n d had a very prominent place. Both as an expert, as a member of different committees,

as a delegate and as chairman and vice-chairman for the North-eastern Area S u n d did valuable work.

S u n d wrote a small book, "Skårungen" (i.e., the young of the gull, but also used as a nickname for a youngster on his first voyage to Lofoten), in the preface of which he says that it is written for all who love the sea, for the youth of all ages interested in sea life, for all who still have the ability to wonder at and to cherish the intricate variety of nature, who are not yet too important to bow down to look at small things, and who have not become too wise to have nothing more to learn. He tells about fishes and birds, sea travel, boats and gear, and also about the importance of good health and a good conscience. With this little book he made for himself an enduring memorial.

One of S u n d' s aims was to perfect the Norwegian fisherman in his profession. He initiated instructional courses, and took a leading part in the development of vocational training for fishermen. On the other hand, he also considered the present structure of the Norwegian fishing community as an essential advantage. This view partly determined his position in the trawling question, and the consequent changes which this would have in regard to the independence of the fishing population.

In order best to conclude this obituary, one may cite what he wrote in the jubilee book at the 25-year celebration of his alumni:—

"As a Norwegian I am grateful to have been born in a country where nature is of a grandeur and beauty so as to make it a fountainhead of health and happiness, whose people one learns to love more and more the more one gets to know them, and whose institutions, with all their faults, stand comparison with those of any other country, while public security is so matter-of-course that hardly anybody gives it a thought. (Perhaps that is why it is not so well guarded as it ought to be).

As a citizen of the world I am exceedingly glad to live in an era when thought and research daily open new worlds to phantasy, when the nightmare of general ignorance is gradually lifting and ageless superstition vanishing. A new conception of the nature and the future of man is dawning upon humanity. In place of the appalling teachings of degeneration, predestination and atonement man is gradually seeing himself in a new light in the conception of his struggle up from bestiality and barbarism to increasing humaneness."

G. Rollefsen.

Wilhelm Nellemose.

1890—1944.

CAPTAIN NELLEMOSE died of starvation and dysentery in a sub-camp of a German concentration camp on the 13th November 1944. The "crime" for which he was imprisoned and maltreated by the Gestapo was that of being a brave man and a good Dane. He knew, of course, what to expect if he fell into enemy hands. He was a leader of the resistance movement which followed the unprovoked attack of the Germans on the Danish army and navy. Seeing that the Germans had chosen to make war on Denmark, it may be

conceded to them that they were entitled, according to the rules, to inflict the death penalty on civilians who resisted them. If Nellemose had been tried by court martial and shot, one might, perhaps, have found some excuse for them, not according to the laws of decency, but according to that peculiar German-invented rule of war that, while it is legitimate to bomb unarmed civilians in their homes, it is a criminal offence for a civilian not in uniform to resist attack. If Nellemose had been tried by court martial and shot, those nearest and dearest to him, and we, his old friends, would be able to feel that he had died as he would have wished, as a soldier fighting for his country. That he did die a soldier's death is true enough, but not as a soldier has the right to die. What, one wonders, are the feeling of those Germans with whom he had worked so long as a colleague, and who had enjoyed his unfailingly courteous help and service? Let us believe, for their sakes, that any of them who are alive to-day are bitterly ashamed and will be for the rest of their lives.

Nellemose was born on 31st March 1890 in Middelfart. His father was an architect. He became a midshipman in the Danish navy in 1907 and, at the age of thirty-three had reached the rank of Captain. In the same year, 1923, he was terribly wounded by an explosion on board the cruiser "Gejser". A demonstration of a new smoke-screen bomb had been arranged for the instruction of a large number of the commanding officers of the torpedo-boat flotilla. The bomb, which should have burned slowly, exploded. One officer was killed and the rest, including Nellemose, were very badly burned. As a result of the injuries he suffered, he became unfit for the naval service and he resigned his commission in 1926.

It must have taken many years to recover from the shock of his injuries, and we know that he must have spent a long time also undergoing the plastic surgery which was necessary for the reconstruction of his injured face.

It was a happy day for the International Council when he entered its service as Administrative Secretary in 1932. From the first he threw himself heart and soul into the administration of the office, which, according to my recollection, he reformed in many directions. In particular I remember that he carried through a scheme for keeping the hydrographic records in photographic form, thus saving much valuable space and facilitating the study of the records themselves.

But this is not the place to record details. I prefer to bear testimony in general terms to his efficiency, his courtesy, and

his warm friendliness. He served the Council with unfailing loyalty for more than twelve years. To one and all, delegates and experts, irrespective of nationality and personality, he was the ever-ready friend and servant. The war bid fair to break up the good work of the Council, but, largely through his untiring efforts, it failed, even as the Germans failed to break his unshakable spirit. Now his body rests in Danish soil not far from the scene of his work for us. That is well. But had it lain elsewhere, the soil that embraced it would have been forever Denmark.

H. G. Maurice.

Jacob Peter Jacobsen.

1877—1946.

JACOB PETER JACOBSEN, the son of a farmer Hr. E. Jacobsen, was born on 23. February 1877, at Skjenkelsø. He studied physics at Copenhagen University and took his degree in 1899. In 1913 he was awarded the degree of Dr. phil. on the strength of a hydrographical thesis entitled "Bidrag til de danske Farvandes Hydrografi" (Contribution to the Hydrography of the Danish Waters).

Dr. Jacobsen made his entry into hydrography immediately on passing his degree examination, when I asked him to assist me with the physical work involved in the determination of the hydrographical constants. These determinations and their calculations lasted for two years, and the results form part of the "Hydrographical Tables" which were issued in 1903

and are still to-day used in practically all hydrographical determinations.

In 1904, Dr. Jacobsen was nominated an assistant of the Danish Hydrographical Laboratory, to which he was attached — with only few interruptions — until his sudden death in 1946. During this long period he published about 40 articles and papers on hydrography and related subjects. Among his papers on a more geographical line may be mentioned "Mittelwerte von Temperatur und Salzgehalt" and "Die Wasserumsetzung durch den Öresund, den Grossen und den Kleinen Belt". He was, however, mostly interested in the physical problems of hydrography.

In his thesis for the Doctor's degree he calculated — probably for the first time — the values of the viscosity coefficient due to turbulence in the waters at Schultz's Grund Lightvessel. He realized the close relation between the intermixture of adjacent water layers caused by turbulence and the virtual viscosity, and he showed that the intensity of mixture is identical for whatever property of a definite unit of volume, i.e., salinity, temperature, or other; the momentum, however, he excepted, the investigations having given a greater intensity of mixture for this property. He explained this peculiarity by assuming that a water mass may oscillate from its natural level and in response to an impulse immediately change its momentum and thus return to its original level with changed momentum, without the water mass itself changing either temperature or salinity in the same degree as the momentum. Later experiences seem to substantiate Dr. Jacobsen's reasoning and results, whenever — as in his experiments — it is a case of vertical turbulence and stable stratification of the water. In several papers he continued these studies of the mixture of adjacent water layers due to turbulence.

His greatest achievements within hydrography he probably attained in his paper "Contribution to the Hydrography of the North Atlantic", published in 1929. In 1916, at a meeting of Scandinavian scientists in Oslo, the Norwegian oceanographer B. Helland-Hansen, had called attention to the fact that curves giving temperature as a function of salinity show an extraordinary similarity in their course, while curves giving temperature or salinity as a function of depth in the oceans may vary strongly. Dr. Jacobsen recognized that such curves, the so-called TS-diagrams, were an excellent means for tracing the origin, occurrence, and intermixture of the water masses of the oceans. Into these TS-diagrams he inserted also isodenses so

that the stability of the various layers could be perceived from the TS-curves in relation to the isodenses.

On the basis of the TS-diagrams Dr. J a c o b s e n made a close analysis of the water masses of the North Atlantic and showed that they could be traced to a small number of characteristic and almost homogeneous water masses and their intermixtures. This method has found many followers and the TS-diagrams form now one of the most important working tools in oceanography. Dr. J a c o b s e n was certainly not the first to use these diagrams, but he was undoubtedly the first fully to realize their value and, through his own work, to recommend them to other oceanographers.

Among his other work may be mentioned his researches into the dissolved oxygen content in sea water, which covered an investigation into the relation of the degree of saturation to temperature and salinity, as well as the standardization of W i n k l e r' s titration method used for sea water.

Dr. J a c o b s e n constructed several new pieces of apparatus, among which especially the Level Current-Meter has been put into use. Current measurements, especially from light vessels, with this instrument have formed the basis of a series of experiments on the currents in Danish waters.

In 1928 Dr. J a c o b s e n was appointed hydrographer to the International Council. In this capacity he achieved many results; he prepared, *inter alia*, an atlas of temperature and salinity of the surface of the North Sea and the English Channel; he worked on the standardization of research methods and assisted in formulating the "Nomenclature and Units for the Indication of the Constituents of Sea Water". He made, furthermore, dynamic calculations of the many data collected during a series of years in the Faroe-Shetland Channel.

Dr. J a c o b s e n regularly took part in the annual meetings of the International Council and met there the most prominent hydrographers of the various countries. He assisted further at the meetings of the International Association of Physical Oceanography, where he made the acquaintance of many new colleagues. In these competent circles his ideas were always listened to with the greatest interest.

Dr. J a c o b s e n' s scientific work will keep his name to posterity. All the colleagues who knew him personally will remember him as a veracious, disinterested and obliging man, a scientist of the purest water who, in his love of research, found the reward for all his trouble.

Martin Knudsen.

The Renaissance of the Individual[1]).

By

Johan Hjort.

The International Ideal.

THE ideal aim of all science is to extend man's knowledge of truth. In so doing there is hope also of furthering social progress and of helping to cement peace among the nations.

Throughout world history there have been alternating periods in the nations' attitude to this international ideal. There have been times when countries have co-operated and times when the world consisted of mutually contending nationalistic communities.

It is in the periods when men hope for progress, when society is in growth, that we can observe an optimistic belief in co-operation. When growth stops or is even reversed, when hope fails, then nationalism raises new acute frontiers between the nations. Even in the "Republic" of P l a t o we find the same ideas, expressed indeed in the same words, about how the State arose by mutual aid and co-operation, as A d a m S m i t h and D a v i d H u m e used about the division of labour and the common interests of nations at the time northern Europe gained new hope of progress 200 or 150 years ago. No less remarkable is it that P l a t o argued that it was the overpopulated State which had to have war, in words reminiscent of R o b e r t M a l t h u s's "Essay on Population".

A wealth of literature on these problems is at present being published in the United States. It sets out to warn all people against nationalism and advocates international co-operation, even a world federation. In a recent book, "The Anatomy of Peace", E m e r y R e v e s says:

"Nothing can distort the true picture of conditions and events in this world more than to regard one's own country as the centre of the

[1]) Lecture given in the *Danske Naturvidenskabelige Samfund* on March 12th, 1947, at the request of the Society's President, Dr. T h. M a d s e n, who asked me to give an account of my research work and to correlate it to the international work in which I have taken part over a number of years. The *Svenska Vetenskapsakademien* has also honoured me by giving me an opportunity to read the paper in Stockholm.

universe and to view all things solely in their relationship to this fixed point. It is inevitable that such a method of observation should create an entirely false perspective. Yet this is the only method admitted and used by the seventy or eighty national governments of our world, by our legislators and diplomats, by our press and radio. All the conclusions, principles and policies of the peoples are necessarily drawn from the warped picture of the world obtained by so primitive a method of observation."

But it is not only in social science that confusion and contention have arisen with regard to the group conceptions which men create. A study of the writings of the other great Greek philosopher, Aristotle, shows that when by a synthesis he had formed a conception of the groups he called species, genera, orders, they bècame for him the real and the primary factors.

And throughout the Middle Ages these conceptions of States and species were victorious. They were even sanctified by the ruling religion. And Linnæus, in his otherwise so admirable work, assumed that the species as they were in his time had been created by the Almighty in the beginning of time.

It can therefore very justly be said of the lectures which Lamarck delivered to young French students a generation after Linnæus, in 1800 and 1801, as of his later "Philosophie Zoologique" (1809), that they represented an achievement of the same revolutionary importance to human thought as the doctrine of Copernicus with regard to the shape and motions of the earth.

"J'ai longtemps pensé qu'il y avait des espèces constantes dans la nature, et qu'elles étaient constituées par les individus qui appartiennent à chacune d'elles. Maintenant je suis convaincu que j'étais dans l'erreur à cet égard, et qu'il n'y a réellement dans la nature que des individus. L'origine de cette erreur, que j'ai partagée avec beaucoup de Naturalistes, qui même y tiennent encore, vient de la longue durée, par rapport à nous, du même état des choses dans chaque lieu qu'habite chaque corps vivant.

En effect, on peut maintenant assurer, que rien n'est constamment dans le même état à la surface du globe terrestre. Or si, relativement aux êtres vivants, la diversité des circonstances amène pour eux une diversité d'habitude, un mode différent d'exister, et par suite des modifications dans leurs organes et dans les formes de leurs parties, on doit sentir qu'insensiblement tout corps vivant quelconque doit varier dans son organisation et dans ses formes."

In the "Philosophie Zoologique" we find the following remarkable statement:

"Les divisions systématiques, classes, ordres, familles, genres et espèces, ainsi que leurs dénominations, sont une oeuvre purement artificielle de l'homme. Les espèces ne sont pas contemporaines: elles sont descendues les unes des autres et ne possèdent qu'une fixité relative et temporaire; les variétés engendrent les espèces. La diversité des con-

ditions de la vie influe, en les modifiant, sur l'organisation, la forme générale, les organes de l'animal; on en peut dire autant de l'usage ou du défaut d'usage des organes. Tout d'abord, les animaux et les plantes les plus simples ont seuls été produits, puis les êtres doués d'une organisation plus complexe. L'évolution géologique du globe et son peuplement organique ont eu lieu d'une manière continue et n'ont pas été interrompus par des révolutions violentes. La vie n'est qu'un phénomène physique. Tous les phénomènes vitaux sont dus à des causes mécaniques, soit physiques, soit chimiques, ayant leur raison d'être dans la constitution de la matière organique."

If we compare these ideas with the Linnæan system we can understand the great importance they had when they became generally known — after L a m a r c k ' s death.

That L a m a r c k was aware that this new starting-point for human thought would have great importance for any international co-operation is seen from this statement (from 1800):

"Dans les relations qui existent soit entre les individus, soit entre les diverses sociétés que forment les individus, soit entre les peuples et leurs gouvernements, la *concordance* entre les intérêts réciproques est le principe du bien comme la *discordance* entre ces mêmes intérêts est celui du mal."

The concord of various interests is what we call the international idea. It must never aim at abolishing discord by force. It requires a plan based on an objectively true foundation which consequently can see "la concordance entre les intérêts réciproques".

L a m a r c k ' s contemporary, B e e t h o v e n, expressed the same idea in these words, "Strength, not force". That is to say, the ideal must be to create the new self, not to achieve one's desires by force.

But is it possible that there can ever be any "concordance" between the vital interests of all nations?

In the period before the movement which came to be known as the Industrial Revolution, 200 or 150 years ago, there was the greatest optimism in Europe with regard to this question. D a v i d H u m e wrote that the internal industry of a nation obviously could not suffer by virtue of a neighbouring country's prosperity, and as in any relatively large country trade was of the utmost importance, so there was no occasion to envy one's neighbours. He went even further, declaring that where there is free contact between the nations the domestic industry would benefit from the prosperity of other countries.

Experience during the past hundred years seems to confirm this view of society. According to W o y t i n s k y, statistics show that the population of Europe trebled or quadrupled in the nineteenth century, and that the people's standard of living was greatly improved.

Yet the utmost dissatisfaction has been expressed at this standard of living during the past hundred years, and in these days it has even been asserted that the unsatisfactory conditions are due to natural science. For all its innumerable inventions have been made in the interests

of "capitalism" and have led to the large-scale industry which gives the individual man such unsatisfactory conditions. "The reason for this," says Aldous Huxley in his book 'Science, Liberty and Peace', "is that there has been more money in working for mass producers, and mass distributors have had more money because financiers have seen that there was more profit for them and more power in a centralized than in a decentralized system of production."

But even the most casual study of the Industrial Revolution must surely lead to the clearest appreciation of the fact that the great discoverers and inventors like Michael Faraday and Justus von Liebig, and medical creators like Jenner and Pasteur, actually were the greatest idealists who derived no benefit from their work that can in any way compare with the values they created. And as for the organizers, the men who created the large-scale industry, it is surely reasonable to ask, Had they not to adapt themselves to the technique which was available; and what would have happened to the people of Europe if the great increase in population had not taken place? Would Europe as a whole have been capable of limiting its population growth like France without going to war like Germany, or would it have had a civilization like that of China, where millions of children are born and die or are killed because there are no means of existence for them?

Present-day social discussion overlooks what Lamarck adduced, that society consists of millions of diversified individuals, each with his different world, needs ("besoins") and capabilities. Plato pointed this out in the grand period of Athens; likewise, that the spheres of work of the various individuals depend on the size of the population, and that therefore no nation should increase its numbers without at the same time enriching the living conditions of the individuals.

In view of this I venture to submit that it is not natural science but social science in our time that has displayed a lack of understanding of the welfare of the individual.

Hence the problem arises whether there is and must be a difference in principle in the human understanding of the methods of these sciences. I venture to assert that the explanation is to be sought in the fact that social science has not yet discovered the method which created natural science — namely, the experimental method. In defence of this assertion, let us look at the experimental method in the two sciences, also because this will explain the basis of the scientific work in the exploration of the sea, which I will refer to later.

The basis of the experimental method in physics, chemistry, zoology and botany is this, that the experimenter in any one experiment may vary only one factor. In his "Leçons sur les phénomènes de la vie", Claude Bernard says that in studying the growth of a plant only one factor may be varied in the same experiment: either light, temperature, moisture, or gas composition in the vessel the plant is in. By many such experiments it is possible to arrive at an understanding of

the plant's life and growth conditions, what Claude Bernard called "le milieu externe". And yet this recognition is also dependent on an understanding of the fact that the plant has a "milieu interne", its heritage from the past created in former times under altogether different and little known external milieus.

In a recent book on the Danish naturalist Johannes Schmidt there is a very interesting article by Øivind Winge which gives a number of examples of how the differences observable in individuals of the same species have in part been demonstrably hereditary, while other characters are conditioned by demonstrably external factors. This proves, like so many other examinations, that the synthetic method (grouping according to resemblances) cannot directly lead to an understanding of the biological groups. A study of the environment (the milieu) and the experiment must verify the ideas.

In contrast to these methods of natural science many kinds of social reformers have maintained their right to vary all the living conditions in one and the same experiment, and completely to disregard what we call heredity and its influence on the individuals. As proof of the correctness of this bold assertion I have referred, in a book on the War which I published in 1945, to a statement by the famous economist Lord Keynes in his article "A Short View of Russia". Keynes refers to Lenin as the great experimenter, who made unlimited use of the method of trial and error. But to accomplish one's ideas by force, such as we experience today where nationalism prevails, is no experiment in the sense of natural science. Nobody has the right to say, like Napoleon, What are 200,000 men to me? Like natural science, social science too must begin with the individual, not with the "masses". And the experimenter, if he wants to create something new, must use the force of example and no other force. He must make inventions which can lead to new progress in society, like Faraday, Liebig, Jenner, and Pasteur; and understand that society consists of individuals, each with different conditions of life.

I will now attempt to illustrate these views with examples from the international exploration of the sea.

International Exploration of the Sea.

It was fortunate for this exploration of the sea that, without being conscious of it, it set out from Lamarck's idea that simultaneous investigations must be conducted of the geographical occurrence of the organisms in the sea and the living conditions found there. Right from the outset it was called "hydrographical-biological investigations". The Swedish scientists Otto Pettersson and Gustav Ekman were foremost in planning this work.

In the 'nineties the waters of the Baltic, the Belts, the Skagerak, and out to the North Sea were studied in co-operation between the three Scandinavian countries. As in the Baltic surface current with its

fresh water mingled with the waters of the north European rivers we found other organisms than in the in-flowing, salter deep-sea current from the North Sea, it was clear that the hydrographical-biological method must have the utmost interest both to the physical-chemical and the biological investigation of the sea. Thanks to K. A. Andersson, the great fluctuations in the Swedish west-coast herring fisheries were explained by the investigation of these sea currents. Subsequent, more extensive investigations increased the conviction that there is no area of the globe which provides the same degree of scope for the study of living things, the individuals and their world. In 1910 I was in charge of an expedition across the Atlantic with the research vessel "Michael Sars". In his report from this expedition, on the plankton, the small drifting organisms, H. H. Gran wrote, "It has often been observed .... that the plankton changes its character the moment one passes the boundary between two currents." It was with this view that the expedition planned to chart the horizontal and vertical extension of the organisms by attaching to one wire, a number of implements to catch the organisms at various water levels.

At all stations in the deep Atlantic there proved to be a definite regularity in the vertical occurrence of the organisms. In the surface level, for example, there were species of fish with large eyes and colours as blue as the sea. In the many clusters of sea-weed which drifted from the coast of America a remarkable fauna was found, both fish, and crustacea and molluscs, all with colouring partly like the sea and partly like the sea-weed. In the fauna in the surface level the occurrence of the youngest stages of fish which live in the lower levels is also important. In the surface level these young stages obtain the food they need from small crustacea, which are much scarcer in the deep zones.

Deeper down is a notable fish fauna with upturned eyes and colours reminiscent of the herring species in more northerly waters. They live in the region bordering on eternal darkness, where small black fish appear with the smallest eyes. Deepest down are the completely blind forms.

After the publication of my account of this vertical distribution of the organisms several zoologists called me a Lamarckist, and compared my description with the ideas of Herluf Winge. I think Denmark may be proud of Herluf Winge, and I consider it an honour to have my work classed with his. By what is called Lamarckism is understood not only the attempt to see the connexion between the geographical extension of the organisms and certain physical conditions of life, but also an attempt to demonstrate the influence of these conditions on the structure of the organisms as an explanation of cause, e.g., the influence of light strength on the animals' colour, eyes, and light organs. In this assertion about Lamarckism there is a fear of the erroneous use of the word "teleology" which Aristotle himself struggled to understand. His problem became quite clear to me when I found in his book on the organs of the animals the statement that

at least one must *try* to appreciate usefulness in living nature. How else can one ponder the problems of life? To prevent any misapprehension the word "usefulness" can be avoided, and instead we can use the phrase "correlation between the living world and its environment"; in doing this we shall doubtless be basing ourselves on L a m a r c k's ideas. But if we dare not do this the whole matter will probably lose all its interest; and that was what I submitted in the last chapter of "The Depths of the Ocean", the report of this Atlantic expedition.

Whatever view is held of the philosophical side of this problem, the task of examining "the individual and its world" everywhere has led to the greatest practical results. This can be proved by glancing at the results achieved by hydrography in charting temperature and salinity in a large sea area, e.g., in a depth of 100 m. in the North Atlantic, and by examining at the same time the fauna found in the whole area. In the first period of the exploration of the sea it seemed a bold thought to assume that the same animal life would be found throughout such great areas. Experience has also shown that in all waters there are special, smaller "environments" for the individual species. The idea must therefore be tested everywhere by local experiments. A particularly interesting example is the experience gained with regard to the occurrence of the deep-sea prawn. This species requires special ocean bottom conditions — the softest mud. Hence special fishing experiments are required to chart the grounds. This charting, from the Skagerak to Spitzbergen, was undertaken by the fishermen themselves, who understood at once what they were to look for. Hundreds of fishing grounds were found in this way. It may not be too bold an assertion, therefore, that *all* new achievements arise like this, a discovery or invention taking place first and then hundreds of others besides the discoverer appreciating the fact that the new idea can be applied elsewhere under similar conditions. The new understanding can thereby spread to large parts of the world — internationally — provided the special pre-requisites for the new work are there. This is the method of natural science applied to social matters.

During the last generation the Norwegian fishery policy, in contrast to that of other countries, has deprived its own countrymen of the individual freedom to try out contemporary technique in the international seas, even off the Norwegian coast itself. This has caused the Norwegian fishermen to lose enormous wealth they might have obtained had the policy respected the freedom of the individual in national and international co-operation.

But how can this extension of organisms in the sea explain the fluctuations which we know take place in the large fisheries? It is understandable that biology, to begin with, assumed that the catch must depend on corresponding differences in the number of fishermen or catchers. For biology was strongly influenced by D a r w i n' s famous presentation of the "struggle for existence" between various populations, in this case the sea's population of fish and the human population of

catchers. On the basis of this idea I also tried to compare the millions of cod caught in northern Norway with the number of fishermen from year to year in the period 1868—1900. But it proved impossible to find any connexion between the fluctuations in these two groups. This gave me the idea that it must be fluctuations in the sea itself which are the cause of the fact that in the same geographical region at various times there is a smaller or larger stock of the same kind of organisms.

The first support for this view was provided by the interesting and valuable investigations of the ice limits in the Northern Sea undertaken by the Danish Meteorological Institute over a number of years. These investigations show big fluctuations from season to season and year to year. In some years, for example, the ice limit has even approached the Finmark coast of northern Norway, where seal, whitefish *(beluga)* and even polar bears appeared. Spitzbergen is sometimes surrounded by ice even in summer, while in other years this large group of islands is entirely ice-free and can be circumnavigated. In the first Norwegian fishery investigations, conducted by that outstanding zoologist O s s i a n S a r s, it was reported that cod-fishing was carried on off Spitzbergen in the 'eighties by small Norwegian fishing smacks. When during my first expedition to Finmark in 1900 I was informed that this fishing was no longer carried out, I made an expedition to Spitzbergen. I succeeded in trawling there among the ice-floes, and established the fact that the whole of the fauna living in temperate water (cod, ling, plaice) had gone. I caught only Arctic fish. But later, in the 'twenties, British and German trawlers made their greatest hauls of cod off the west coast of Spitzbergen and Bear Island. For a few years then the whole of Spitzbergen was free of ice.

Corresponding fluctuations in the ice conditions and the occurrence of the cod shoals have been found by the Danish scientists A d o l f J e n s e n and P a u l H a n s e n off the west coast of Greenland. In 1924 I myself made a brief expedition to the waters there and had an opportunity of seeing the great mass of cod there at the time.

But it is not only the fishing sea and the geographical extension of the stock which are subject to these big fluctuations. Examinations of the age composition of the fish stock have shown that in many species of fish large fluctuations occur in the numerical size of the year-classes. A stock of herring and cod like that of the Northern Sea may in many successive years consist to a large extent of one and the same rich year-class. In my first description of this phenomenon (in 1914) I put forward the hypothesis that the numerical size of the year-classes depended on the conditions of existence found by the newly laid eggs and larvae in the week or weeks when they have to obtain their first food from among the microscopical plants and crustacea living in the surface of the sea. This hypothesis found wide support and it has now been given experimental confirmation by G u n n a r R o l l e f s e n's success in getting eggs of the small crustacean *Artemia* to develop along with cod or flounder larvae. These thus obtain the food they require and hence

can survive the first critical stage of life. It is possible to breed in relatively small vessels thousands of the first bottom stages of the flounder species, which can be planted out and again recovered in the sea, thus giving experimental confirmation of the continued life in the sea of this artificially produced "year-class".

How comprehensive these phenomena are was brought home to me in 1914 when I was invited by the Canadian Government to investigate the age composition of the fish stock in the Canadian waters. I found there the same age composition as in the Norwegian waters; for example, in herring there was the same rich year-class (1904) as in the Norwegian spring herring. This tempted me to believe that there is the greatest conformity over large areas of the northern Atlantic waters.

In my reflections on these experiences I have often asked myself, If the sea really keep the older stages of a new, rich year-class alive over a large number of years, as soon as they have survived the first critical stage will there not often be "under-population" in the sea, a smaller number of individuals than the sea can really maintain, unless a new, rich year-class "happens" to have been formed? Should this be the case, is the exploration of the sea not now faced once and for all with the possibility not only of finding and gathering what the sea itself brings forth but of being able actively to produce a greater wealth than that which nature herself produces?

These problems are specially apropos today because in large trawling waters like the North Sea it is alleged that over-fishing is threatening to reduce the stock to a size which will no longer allow of continued working.

That more intensive fishing has been done than the stock could bear is shown especially by the experience of whaling. A survey is afforded by the statistics of the brief Norwegian whaling off the Spanish coast. They show that the catch per whaler rose rapidly to a maximum, then soon dropped to a minimum. Yet the whaling companies continued to send more whalers out, with the result that the operations very quickly ceased altogether.

This calls to mind D a r w i n ' s celebrated remark that in the struggle between two populations, in this case the whales and the whale-catchers, one of them is first so heavily reduced that the other, the victor, must cease to exploit the reduced stock until it has grown afresh and has become so rich that catching can begin again.

In this way, the representatives of the trawling industry in the North Sea are recommending that the tonnage, i. e., the fishing fleet, should be reduced by State action in order to give the stock a new chance. But the great difficulty of this suggestion is that fishing in the North Sea is not so uniform an operation as whaling. There are many kinds of populations both in the fish and among the fishermen. This becomes quite clear from a mere glance at the fisheries of the Scandinavian countries with their manifold types of craft, equipment, and catches. It is not one, but many kinds of fisheries; and the attempt to find a

common denominator for an optimum regulation of these complicated operations by national or international State regulation is consequently leading to conflict between the various State interests, even in the international sea outside the territorial limits. At present at any rate it is impossible to find any concord; discord will arise among the nations if the States set out to regulate the tonnage of fishing fleets.

Fishery investigations, therefore, have hitherto aimed at finding new grounds, and in the past 50 years this work has been successful so that new progress and fresh wealth have arisen.

Are we faced today with a sharp limit to these objectives? There are many signs to suggest that fresh discoveries can be made. Up to now the catches have taken place along the sea bed, but there are signs that in the great ocean depths, with new methods such as "asdic", echo-sounding apparatus, and the like, pelagic fish can be found, above all of the herring species. And in us, who have tried for so many years to find new possibilities, this has given rise to doubt as to whether the State should now have the power to introduce what it, perhaps erroneously, might consider to be the "optimum" catch and fishing fleet.

It is obvious that under these conditions it would be a splendid task for sea research if it could itself help to increase the stock of fish in the sea by creating new, rich year-classes. It is such a hope that has kept the so-called planting stations alive for so many years, although they only put out larvae in the first stages of development, whose fate was quite uncertain and whose importance to the stock could not be demonstrated. The problem today is, whether on the basis of new experience, these questions can be solved by altogetheer new methods.

Can the experience and problems sketched here in all brevity throw any light on the relation between natural science and social science?

Natural Science and Social Science.

Will it benefit future social science if natural science can explain how the discovery of new ideas can best be applied to the benefit of mankind? None of us can, probably, make a better contribution to the solution of this fundamental question than by frankly discussing the experiences he has had in the cases where success has been achieved in occasioning something new.

In contrast to the claims of so many social systems I have found that society as a whole has never readily subscribed to new ideas but that there were always individuals who accepted them, not merely with the object of earning money but because they were interested in them. And they were the men who made the new inventions, or extended our experience by new discoveries. They found, for example, new fishing grounds where there was the same sort of animal life and the same natural conditions as others had found before them. They made their own discoveries available to others. When they had charts sent to them they were returned inscribed for publication with new grounds. But

progress did not depend on this interest of the individuals alone. It also depended on the availability of the instruments required to apply a new method.

As an example of these claims I should like to refer to the following experience from my work for the development of the new fishery for the deep-sea shrimp *(Pandalus borealis)*.

When I was invited to the 300th anniversary of the foundation of Harvard University in 1936, being at the same time offered the use of that fine research vessel "Atlantis" off the New England coast for a fortnight, I asked one of my Norwegian friends among the shrimp fishermen whether he would accompany me and assist me with his practical experience. "I'm afraid I can only pay for your journey," I said. "Oh, but that's nice," he replied. And when we found the new grounds he was as pleased as I was, though he had never thought of fishing over there.

I make so bold as to declare that this, and many other experiences in the solving of problems, small though they be in relation to the great social questions, demonstrates unmistakably that there is among free men a joy and a readiness for sacrifice in the cause of progress, and that nothing is more fatal for a nation than to violate the freedom of individuals on the strength of general ideas or "isms".

Next I should like to refer to the industrial evolution already mentioned. For many years the new fishing industry remained more or less unchanged. Why? Because the trawl had to be hauled by hand. But then there suddenly arose a new development; the small smacks were fitted with motors for propulsion and for hauling the gear. When these new technical appliances were introduced, the curve of catches rose rapidly to about 4,000 tons a year. When Aldous Huxley alleges that big-scale industry is due to the money interests of financial people it is clear that he has no understanding of the fundamental effect of the technical problems on the methods and progress of operations. Progress is not produced by moral but by technical changes.

The decentralization of industry which Huxley demands will probably never be realizable in all undertakings by technical methods. For example, Antarctic whaling cannot be conducted with small one-man smacks. The Scandinavian fishermen and whalers, however, have solved this problem by what they call the share system. The men taking part in a large fishing enterprise do not get a daily wage but a share in the yield. It often exceeds even the annual salary of the highest paid Government officials and gives the thrifty man in many cases, if he so desires, an opportunity to own his own craft, where the army of tax collectors does not deprive him of most of his money. Both in Denmark and in Belgium I have met fishermen who owned several motor trawlers which they had bought without any State grant. To what extent this system can be applied in other industries is a problem which was once formulated in "Nature" as, Can everybody become boss of something? That we men differ greatly in our desire and ability to have charge of

an independent but small enterprise or a part of a larger, more complicated undertaking, does not prevent technical and social science co-operating to exert the utmost effort to solve this problem as far as conditions permit.

How do we stand today? In his book referred to above R e v e s says, "The innumerable international conferences, which are held almost every month, are nothing but the epileptic convulsions of the incurable infirm system of nation-states. Every few weeks a new crisis arises in which 'public opinion' childishly clamors for another meeting of the leaders, expecting a miracle — an agreement between the national governments that would cure the disease. Every time, they get an empty insignificant communiqué" . . . demanding another conference.

Is this a retrogression to the period prior to the great advance in population and technique which is called the Industrial Revolution? Is it a return to the period before A d a m S m i t h, D a v i d H u m e, L a m a r c k, K a n t, and G o e t h e? Does not the national policy recall L i n n æ u s' s conception of the species as created by the Almighty? If so, may not salvation come by social science and politics also realizing the truth of L a m a r c k ' s words that in nature there are only individuals, and recalling G o e t h e ' s celebrated phrase that it is the variety of the individuals which is nature's great device for creating a rich life? "Equality" only applies in relation to society's laws.

The problem today, therefore, is to create States which recognize "liberty and fraternity" in spite of individual variety at home and abroad. This was the idea that was fermenting in K a n t' s "eternal peace" and in his "final peace articles", which assume joint legislation, legal ideas and right to work for the most varied individuals in all countries. And far removed from Königsberg, in the 13 first American States, these ideas were materialized. All the States relinquished their absolute sovereignty in favour of the Federal State where K a n t' s final articles of peace were to prevail and subsequently have prevailed. Thereby was created the "concordance" of which L a m a r c k had dreamt. Would not freedom and peace both be promoted on this basis and not by power (discordance) and atomic bombs? Strength — not force! Progress from below, not from above!

Note on the Spectroscopic and Biological Detection of Potassium in Sea Water and "Potassium-Free" Artificial Sea Water.

By

W. R. G. Atkins.

IN one kilogram of sea water of salinity 35 $^{0}/_{00}$ there are 10·769 g. sodium and 0·387 g. potassium, also 0·408 g. calcium. The intense colours produced by sodium and calcium in the flame test quite mask the lavender-blue potassium flame. This can be revealed with a blue glass or more strikingly by a 6·7 mm. filter of unpolished Corning didymium glass, which has such a strong absorption band for sodium that its flame colour disappears completely, while leaving the spectrum otherwise little altered.

"Potassium-free" artificial sea water was made up using salts supplied by Kahlbaum, pure for analysis, and the British Drug Houses, analytical reagent quality. Such artificial sea water was found by F. A. Stanbury (1934) to produce, when inoculated, up to six diatoms in the haemocytometer field; this, however, gives 60×10^{9} per cubic metre, the usual unit of volume used in recording the concentrations of the minor constituents of sea water. Results obtained with added potassium salts gave as the requirement of one *Nitzschia closterium* W. Sm., $1{\cdot}3 \times 10^{-14}$ g. of potassium. From this one finds that the potassium present as impurities in the reagents and introduced into the "potassium-free" solution was 0·78 mg./m.^{3}, an amount far smaller than can be determined by any gravimetric or colorimetric method of analysis though 0·5 mg./m.^{3} of phosphorus can be detected colorimetrically.

I am indebted to Mr. F. Twyman F.R.S. for kindly undertaking to see whether potassium could be detected by the best spectroscopic technique. The artificial sea water was sent in a fused silica flask with a waxed cork and the examination was made by the staff of the British Scientific Instrument Research Association as reported by Dr. H. Moore, using a D. 78 Hilger wave-length spectroscope. A quantity of the sample was evaporated down to a paste with which the positive

carbon was charged at intervals, but the potassium lines 4044 and 4047 Å could not be seen. Mixtures were then made of one part of potassium chloride to 100, 1000, and 10,000 parts of sodium chloride. "The potassium lines could be seen clearly with the first, and could be identified with certainty with the second mixture provided the arc, when first struck, was central with the carbons so that its image fell accurately on the slit of the monochromator. With the third mixture, however, we were quite unable to identify the potassium lines after repeated trials, although the iron line at 4046 Å could be clearly seen at intervals." It was suggested that the potassium lines in the ultra-violet might be identified using a quartz spectrograph. Later, at Dr. T w y m a n's suggestion a search was made for the red lines in the potassium spectrum at 7699·0 and 7664·9 Å, the dried-down material being heated on a platinum wire. This was "unsuccessful, partly on account of the considerable amount of glare in the spectroscope, and partly on account of the low intensity of the lines given by the flame. As the glare seemed excessive it was suspected that there was some filming of the object-glass of the collimator and that the prism was not perhaps in the best position. After cleaning and re-assembling, the glare was found to have been much diminished, but it was still not possible to see the red lines of potassium in the flame spectrum. However, in view of the marked diminution in glare the observations previously made with the arc spectrum were repeated. It was not possible to identify the blue potassium lines 4047·2 and 4044·1 Å, but provided the amount of salt used to charge the positive carbon was fairly considerable it was possible to identify, without question, the two red lines of potassium. There was still a certain amount of glare in the field of the telescope, and the red lines could only be picked out faintly against this glare. By interposing a red selenium glass between the arc and the slit of the spectroscope the whole of the sodium light was cut off and the glare disappeared almost entirely. It was then possible to show the lines to an entirely inexperienced observer.

Every precaution was taken to avoid contaminating the artificial sea water. It was concentrated in a silica crucible and applied to the carbons by means of a silica rod, and the carbons were tested to see that the two red potassium lines were not present in the arc spectrum given by the carbons alone." Dr. T w y m a n considered that the detection of so small a proportion of potassium was beyond what had heretofore been accomplished in the presence of so much sodium.

It therefore appeared of interest to see whether potassium could be detected in the artificial sea water rendered still further "potassium-free" by growing diatoms in it. As already mentioned it contained, as prepared, 0·78 mg./m.^{3} according to the biological method of analysis. From the figures already quoted for the amount of sodium in sea water it results that in the "potassium-free" artificial sea water the ratio of potassium to sodium was rather less than one to ten million, actually 0·72 parts of potassium. The method of sub-culture in the artificial sea

water led to no measurable increase in the potassium concentration of the diatom cultures due to the inoculation from ordinary sea water. There was of course no inoculation in the sample spectroscopically examined at first. The sample depleted by diatom culture was prepared by centrifuging off the cells after they had reached their maximum development as shown by haemocytometer counts.

Before going on to the diatom-depleted sample a further trial was made with the original solution using the Corning didymium glass to reduce the glare due to the sodium present. When the carbons were charged with the almost dried residue from the artificial "potassium-free" sea water, the violet lines were not detected. When, however, the carbons were charged with a potassium salt, the interposition of the didymium glass did not appreciably affect the visibility of the lines, 4044 and 4047 Å. But the didymium glass definitely impairs the visibility of the red lines 7665 and 7699 Å. With the carbons only slightly charged with the residue from the artificial sea water the lines could not be seen with certainty when the unpolished didymium glass was mounted in front of the spectroscope slit. They showed faintly but clearly without it and could still be seen through the red selenium glass. When the carbons were comparatively heavily charged with the residue the lines could be seen with the didymium glass in position. The didymium glass would be useful in cutting off glare when observations are being made on the violet lines. But a further cleaning and re-adjustment of the spectroscope reduced the glare still more in the violet region and to a lesser extent in the red, though even here it was still much less than in the previous work. Interposing the didymium glass between the arc and the slit of the spectroscope made the glare in the blue region negligible and reduced the glare in the red region to an appreciable extent, though by no means completely. With the red selenium glass the glare due to the sodium light was completely cut out, without noticeably altering the intensity of the red lines. Thus for detecting traces of potassium Mr. P h i l p o t and Dr. H. M o o r e recommend that spectroscopic observation be made on the red lines 7665 and 7699 Å rather than on the blue lines and that a red selenium glass filter should be used in front of the slit of the spectroscope to reduce glare.

A sample of exhausted "potassium-free" artificial sea water was then prepared and sent as before. Observations were made on half the liquid boiled down in a new Vitreosil crucible which had previously been boiled for some minutes in several changes of distilled water. The two potassium lines 7699 and 7665 Å, previously absent, were present in the spectrum of the carbon arc after the carbons had been charged with the residue. The experiment was repeated with another new Vitreosil crucible; the result was the same.

As a further check the carbons were then charged with potassium chloride, when the same two lines were strongly shown. Then barium chloride was put on to the carbons to show the two barium lines 7673 and 7645 Å, in order to make sure that the setting had been correctly

on the potassium lines and not by any chance on the two adjacent and similarly situated barium lines.

It was very surprising that any potassium should have been detected in the exhausted potassium-free sample, that is to say, in water in which *Nitzschia* had multiplied as far as it would, in the presence of all other substances necessary for multiplication. It was shown that on adding a potassium salt only, multiplication was resumed. The potassium present should therefore have been far less than 0·78 mg./m.^{3}, or in the 100 ml. sample under one-tenth of a microgram, as this was in the unexhausted solution. It may possibly have been that some of the cells had died and the potassium content had largely diffused out, diffusion being very rapid in the case of such small objects. Also unfortunately a small tube used in centrifuging off the diatoms from the culture solution cracked and it is possible that the cracked surface gave off the trace of potassium requisite for detection. Circumstances have so far prevented any repetition of this test, but even without this examination of the exhausted solution the results obtainable by the best spectroscopic technique are so remarkable as to merit notice.

Summary.

1. Biological analysis by growth of *Nitzschia* showed the "potassium-free" artificial sea water to contain 0·78 mg./m.^{3}, namely, less than one part in one-thousand million.
2. The Staff of the British Scientific Instrument Research Association were unable to detect the potassium lines 4044 and 4047 Å in the dried residue of this solution using a Hilger D. 78 wave-length spectroscope. At F. T w y m a n's suggestion they sought the red lines 7664·9 and 7699·0 Å and found them after reducing glare by a most careful cleaning of the instrument and use of a selenium red-light filter with a carbon arc source, though not with a gas flame.
3. It was similarly possible to detect the red lines of the potassium spectrum after the culture solution had been exhausted by diatom growth. It is possible, however, that there was contamination by diffusion from dead cells or from the glass of a centrifuge tube which broke during the removal of the cells.

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Some Simple Instruments for Manipulating Small Plankton Organisms.

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DURING the examination of plankton under a binocular or low-power microscope it is frequently necessary to transfer a single small organism, such as a Radiolaria or nauplius, to a small drop of water for more detailed examination. To do so without damage to the perhaps delicate structure of the organism it not always easy if fine forceps are used. Brushes tend to remove far more than the intended organism, which is itself often difficult to remove from the brush, and needle-points frequently fail to bring the object through the surface film. I have found that the eye of a suitably modified needle is very effective for this purpose, but the needle requires to be bent so that the eye can be used horizontally in the dish while the handle into which it is mounted is at a convenient angle for manipulation.

Sewing needles, as they are sold, are too keenly tempered, and break when an attempt is made to bend them. It is therefore necessary to heat the needle very carefully over an extremely low flame until it becomes bright blue. It may then be bent, while cold, to the desired angle. This degree of temper is also an advantage in operation as needles are then not hard enough to be brittle nor soft enough to bend accidentally, being sufficiently springy to withstand the slight strains. It is an advantage if the needle, after being tempered and mounted, is rubbed down on a hone to form a fairly sharp chisel-shaped end that can easily be slid under organisms resting on the bottom of a dish (see Fig. 1, A, B, and C).

The needle-eye is slid under the object to be picked out and carefully lifted, the whole operation being done under the binocular or other lens. The organism rests on the eye and is not so easily washed

off during the removal process as it is from a needle-point or from a flat type of lifter. Moreover, capilliary action ensures that a small globule of liquid is also lifted out so that the organism is not subject to strain or drying while in transit.

There is a good range of sizes available. I find the following sizes of British-made needles of most use, although there is variation in the actual size and shape of the eye in relation to the needle size. The figures given in the table are approximate only but give a good indication of the size to be expected.

Needle Number	Diameter in mm.	Size of Eye in mm.
4	·84	·4 × 1·2
8	·57	·3 × ·8
12	·33	·17 × ·5
20	·22	·12 × ·33

The needle chosen for the operation should normally have the width of the eye smaller than the object to be picked out, but an organism even considerably less than 120 μ can, with a little practice, be picked out by incorporating it in the minute globule of liquid that clings to the eye. The organism floats off the needle as soon as it is immersed into the drop on the microscope slide or watch glass. If, however, as occasionally happens, the organism is of such a size that it becomes wedged in the eye, it may be pushed out with a needle point.

Needles may be mounted in any of the usual ways, but I find Professor R o s e's method (R o s e 1933) very effective. In this method, suitable pieces of glass tubing are drawn out and cut so that the fine opening is rather larger than the diameter of the needle, which in this case is, of course, inserted point first. The needles should be tempered and bent before insertion. Powdered sealing wax is dropped into the tube from the other end and pushed with a suitable stiff wire into the point, where it is melted very slowly, thus sealing the needle in position.

If the wax is melted too rapidly the gases produced force the wax up the tube and so prevent the formation of a solid block at the tip. The heat should be applied behind the wax so as not to affect the temper of the needle. When cold, the other end may be smoothed in a flame but should not be sealed. Should the needle break at any time a new one may be inserted into the same handle by merely melting the sealing wax, but if the other end is closed the expansion caused by the application of heat would force the melted wax out through the orifice. Different colours of sealing wax can be used for different sizes of needles so that a suitable instrument can be picked up at a glance. It is easy to make handles to suit one's own individual preference. Professor R o s e prefers tubing 8 to 10 mm. external diameter and about 12 cm. long. I prefer much smaller handles of 4 mm. external diameter and 8 to 9 cm. long.

Larger organisms, such as fish eggs, trochophores, etc., can be picked

out on instruments made by fixing a loop of horse-hair into similar handles, but the bend is best achieved by drawing the glass tube at the requisite angle (Fig. 1, D).

These instruments are also used for transferring organisms from one reagent to another when staining or mounting.

For dissection, Professor R o s e uses entomological pins, No. 000, mounted in the above fashion, but I find these too soft and easily

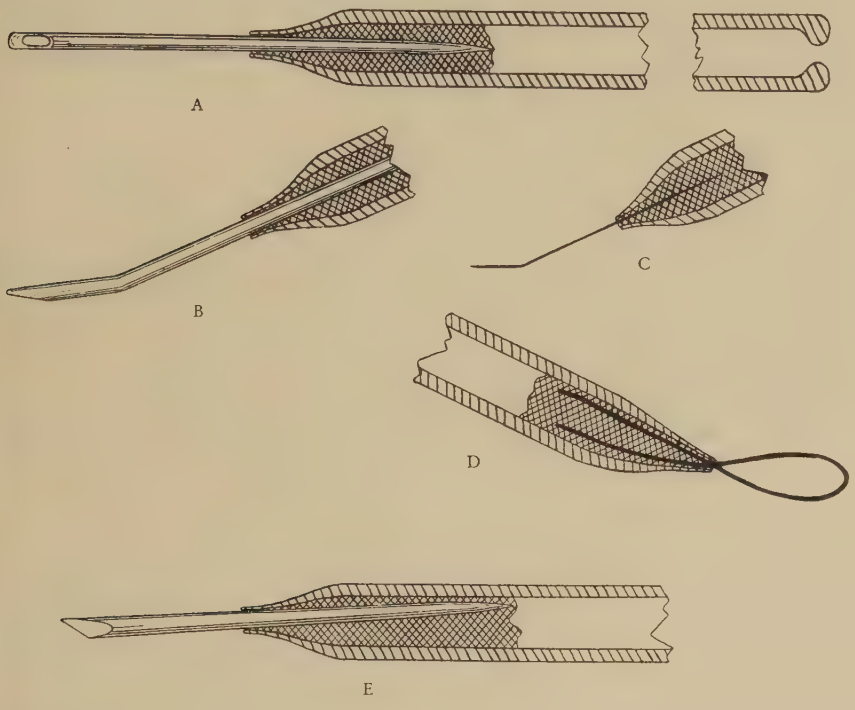

Figure 1. A: Needle eye, No. 4 size, mounted in glass tubing. B: The same, seen from the side. C: No. 20 size needle to same scale. D: Horse-hair loop. E: Fine knife made from a needle.
All figures about 2½ times natural size.

distorted. I use sewing needles of various sizes but the temper of the finest ones (No. 20) requires to be reduced to make them less brittle. The needles should be held by the point in small pliers and heated over a very low flame (about 5 cm. above the lowest gas flame that can be maintained in a Bunsen burner) until the shaft is bright blue but the point is straw-coloured or untouched. This makes the needle pliable in use, but it will not become permanently distorted and the point is durable. Needle points can be touched up on a hone as required.

Fine knives may be made by breaking off the eye of untempered needles and mounting these point first. The broken end may then be

ground down at an angle of about 45° to form a knife with a blade of 1 mm. or less (Fig. 1, E). Such knives are useful for removing the appendages of copepods, dissecting out the stomach contents of larval fish, and operations on a similar scale.

The colour of the sealing wax can again be used as a distinguishing character, and by mixing powder of different colours a marble effect is produced, so that a great range of distinctive varieties can be made from a few stock colours.

'Blued' steel does not rust as easily as the 'unblued' but the eyes, especially, of fine needles should be free from moisture before being put away after use. Dipping in alcohol containing 1 part in 20 of light machine oil is quite effective.

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Recherches sur le cycle du *Coccolithus fragilis* Lohm., Flagellé dominant des mers chaudes.

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EN mer chaude et profonde, le cycle du plancton est très différent des phénomènes classiques observés dans l'Atlantique tempéré, aussi bien comme facteurs de production que comme espèces dominantes. Il reste, en outre, relativement mal connu, et le présent article est une contribution à son étude. Les faits les plus précis furent établis à Monaco en 1938—39, et quatre ans de mobilisation aux armées ne m'ont pas permis d'y ajouter beaucoup durant la guerre. Cependant, d'assez nombreux dosages et prises d'eau, effectués au large d'Alger en 1942 et 1946, confirment l'ensemble des résultats précédents.

1. Rappel des données antérieures.

Depuis les travaux de base de Lohmann (1903 à 1921), on sait que les Flagellés calcaires (ou Coccolithophorides) forment une part notable de la masse de plancton au litre, en Méditerranée comme dans l'Atlantique central, et jusqu'aux plus grandes profondeurs. Hentschel (1936), opérant par centrifugation de l'eau de mer et comptage des cellules, montre le rôle quantitatif prépondérant de cinq ou six espèces, notamment *Coccolithus fragilis* au large des côtes occidentales d'Afrique. Ercegovic (1936) et Kamptner (1937 à 41) trouvent en Adriatique une flore variée, où ce *Coccolithus* semble plutôt rare. Pour les parages de Monaco, Banyuls, Alger, il est par contre pérenne et dominant de 0 à 1,000 mètres. La croisière du "Président Théodore Tissier" de 1936 en a aussi récolté beaucoup au voisinage des Açores et du Sénégal.

Il s'agit donc d'un élément essentiel du nanoplancton, en Méditerranée occidentale et dans la moitié est de l'Atlantique chaud. A Monaco, *C. fragilis* fait à lui seul 36 % du volume moyen annuel de Protistes par litre, et ne manque jamais dans l'eau, puisque sa proportion varie de 5 à 70 % selon l'époque. Ses squelettes constituent souvent la majeure partie de la vase profonde, grise et molle, entre 50 et 2,000 mètres.

L'étude détaillée de ce Flagellé paraît donc nécessaire pour analyser les causes de fertilité régionale, d'autant plus que la plupart des petits animaux pélagiques (Copépodes, Salpes, Chétognathes, larves diverses . . .) avalent les cellules ou les spores du *Coccolithus:* leur tube digestif en est souvent coloré en rouge-orangé vif, et semble digérer cet aliment.

Plusieurs publications personnelles (F. B e r n a r d, 1939, 1942, 1943) retracent les variations de forme et d'abondance du *C. fragilis.* En 1942, j'ai tenté une synthèse des connaissances sur la biogéographie des Coccolithophorides, d'après toutes les expéditions qui avaient signalé de tels Protistes. On peut résumer en quelques lignes les faits très généraux:

1. *Coccolithus fragilis* est un Flagellé calcaire assez gros: les cellules habituelles mesurent de 15 à 40 μ, et il atteint exceptionnellement 130 μ. Toujours présent dans les régions où il est commun, il donne au litre une densité de 300 à deux millions d'individus, en y comprenant tous les stades, qui sont très variés.

Le stade "adulte" banal est mou, ovoïde, avec 60 à 200 plaques perforées (trémalithes), non soudées entre elles. Il peut se reproduire, soit par divisions sous coques gélatineuses épaisses (palmella), soit par spores internes granuleuses de 5 ou 6 μ, très opaques (noires ou rouge-orangé) (Fig. 1).

Ces trois phases (adulte ovoïde, palmellas, spores) sont les seules abondantes près des côtes. Au large (à plus de 20 km. du littoral), les palmellas deviennent rares, les spores moins communes, et le stade résistant paraît surtout constitué par de vrais k y s t e s calcaires exogènes très sphériques. De plus, l'adulte nageur du large n'a que 7 à 20 plaques, soudées entre elles.

2. Jusqu'à présent, il a été impossible d'obtenir *C. fragilis* en culture au laboratoire: même en prélevant l'eau avec toutes les précautions d'usage, les cellules meurent, ou font des spores qui n'éclosent pas. La reconstitution du cycle naturel est donc théorique, mais basée sur l'examen de près de 2,000 échantillons d'eau, chacun avec des milliers d'individus. La forme du large, pourvue de kystes, ne peut être séparée de la forme côtière en une "espèce" distincte, car j'ai vu de nombreux termes de transition entre elles. Avant 1938, les spécialistes (S c h i l l e r, L o h m a n n) ne connaissaient que l'adulte sphérique du large et les amas palmelloïdes: la découverte de kystes et de spores est donc récente (et place les Coccolithophorides assez loin des véritables Chrysomonadines, à kystes siliceux endogènes).

3. Le *Coccolithus* étudié est, d'après les données du "Meteor", particulièrement résistant aux variations de salinité et d'oxygène, sans doute grâce aux spores ou kystes rapidement fabriqués. Je crois difficile de considérer sa biologie comme uniforme dans tous les Océans: non seulement il doit exister en surface des "races physiologiques locales", mais encore, à Monaco, les exigences de milieu en profondeur se révèlent bien spéciales. D'après mes observations saisonnières, tout se passe comme si les cellules du niveau 350 mètres, remontées par les courants ascen-

dants, étaient incapables de peupler les couches superficielles, et réciproquement.

Ainsi, l'habitat de cette espèce, très large en apparence (températures limites, 10 à 32°; salinités, 31·5 à 39 $^0/_{00}$; profondeur, 0 à 3000 m.) se résoud probablement en secteurs nombreux, chacun peuplé par une race physiologique spécialisée en surface, les types de profondeur étant peut-être plus homogènes.

Dans ce qui va suivre, nous insisterons sur le cycle au large de Monaco et dans les eaux éclairées, confirmé par des prises d'eau à Alger et Banyuls-sur-Mer. Le problème, encore plus complexe, des éventuelles "races profondes" sera examiné plus tard.

2. Matériel et technique.

En 1937 et 38, des prélèvements d'eau par bouteille Richard étaient faits à Monaco, une fois par semaine aux niveaux 10, 50, et 200 mètres, une fois par mois à 500 et 1000. Fixée, sur le bateau, au formol neutre à 4 $^0/_0$, cette eau était mise à sédimenter dans des vases étroits, puis le dépôt examiné au microscope inversé pour numération des Protistes, au microscope normal pour détermination des Flagellés.

Selon la même méthode, des échantillons d'eau furent pris à Banyuls (Pyrénées orientales) en 1938, à 10 et 50 mètres. Enfin, comme éléments de comparaison, j'ai eu sous les yeux les récoltes suivantes:

45 échantillons d'eau, région des Açores et du Sénégal (croisière du "Président Th. Tissier" en 1936, profondeurs 50 et 350 mètres);

15 prises d'eau au large de Biarritz (Golfe de Gascogne) à 10 et 400 m.;

50 au large d'Alger en 1942, à 10, 50, et 200 mètres.

Au total, plus de 2,000 échantillons d'eau, en toutes saisons, permettent une première esquisse du cycle du *Coccolithus*. Pour les facteurs physico-chimiques de la production, les renseignements les plus complets proviennent de Monaco, où diverses données furent obtenues:

Vents moyens, pluie et durées d'insolation, grâce à la station météorologique du Musée Océanographique;

Salinité totale (méthode de K n u d s e n) — températures de l'eau par thermomètre Richter à renversement — teneur en phosphates (procédé colorimétrique Denigès-Atkins) — en nitrates (à la strychnine réduite).

Enfin, nous avons évalué l'éclairement moyen par semaine en surface, en se basant: 1° sur les mesures effectuées à Monaco avec un luxmètre à cellules, de 0 à 100 mètres de profondeur; 2° sur les durées d'insolation par jour, mesurées par la station météorologique. Ainsi évalué, l'éclairement moyen de la semaine varie de I (minimum de Décembre) à 20 (maximum de Juin). Ces unités sont arbitraires, en raison de l'étalonnage imprécis des cellules, mais permettent déjà une comparaison intéressante entre les diverses semaines de 1938.

En fonction de ces facteurs du milieu, nous allons étudier, non pas des nombres de cellules par litre, mais leur v o l u m e, estimé d'après la

taille moyenne de chaque stade et son abondance au litre. En effet, la méthode habituelle par nombre d'éléments renseigne très mal sur la production réelle de *Coccolithus*, le diamètre de ce Flagellé variant de 5 à 130 μ selon les stades (Fig. 1): peu de grosses cellules représenteront ainsi autant de matière organique que des milliers de spores minuscules à d'autres époques. J'ai calculé d'après ce principe: 1° la proportion volumétrique des *C. fragilis* dans le total du nanoplancton; 2° le pourcentage, en volume, de chaque stade (spores, palmellas, etc.) dans le total des formes de l'espèce. Quelle que soit l'imprécision de ces calculs de volumes (comportant des erreurs relatives de plus de 10 %), ils donnent, sur la fertilité marine locale, des renseignements moins inexacts que le simple comptage des cellules, procédé qui ne tient aucun compte de leurs dimensions respectives.

3. Schéma général du cycle. (Fig. 1).

D'après la chute des cellules sans flagelles, et surtout des spores, dans des vases d'eau de mer, il est permis de croire que le *Coccolithus* est un peu plus dense que l'eau: il ne se maintiendrait à un niveau constant que grâce à l'action des courants horizontaux, rarement nuls en pleine mer, ou peut-être par le battement des flagelles. Sans celà, il descend passivement, à une vitesse d'environ un mètre par heure.

Il se pose donc le problème biologique du cycle vertical: un Flagellé de surface, tombé ainsi à 200 mètres ou plus, est-il capable de prospérer dans l'eau profonde où il arrive? La réponse est encore incertaine, car, sauf dans la couche "tyrrhénienne" dont il va être question, la morphologie du squelette calcaire semble homogène, de 0 à 2,000 mètres. D'ailleurs, même si les cellules changeaient de structure avec le niveau, celà ne prouverait pas qu'il s'agit de "races" différentes suivant les couches. Dans le travail biogéographique de 1942 (page 91), j'ai résumé les premières notions sur l'influence du milieu, concluant, à titre d'hypothèse, à l'existence de quelques races spécialisées en profondeur. Probablement, les cellules, spores ou kystes tombés trop loin de leur niveau habituel ne peuvent se reproduire dans leur nouveau milieu, et doivent être ramenés en surface par des courants ascendants pour proliférer. En tous cas, le nombre d'individus recueillis en bon état sur le fond est toujours considérable, et la plupart d'entre eux proviennent sans doute de chutes passives.

Quoi qu'il en soit, l'abondance globale du *C. fragilis* est grande à tous niveaux: à Monaco, son volume total par litre (moyenne annuelle 1938) est évalué comme suit:

à 10	mètres:	0·048	millimètre-cube,	soit 36 %	du nanoplancton moyen;
à 50	—	0·038	—	— 33 %;	
à 200	—	0·027	—	— 24 %;	
à 350	—	0·036	—	— 37 %;	
à 500	—	0·035	—	— 45 %;	
à 1000	—	0·040	—	— 50 %.	

La production change donc relativement peu avec la couche étudiée: observons cependant un minimum à 200 mètres, couche favorable à d'autres Protistes concurrents, et un maximum à 1000.

Sans insister plus longtemps sur les variations en profondeur, voici, un peu schématisé (Figure 1), le cycle probable en surface (0 à 50 mètres), d'après les résultats établis à Monaco, Banyuls, Alger, confirmés par quelques prises au large du Sénégal.

Il convient de séparer la zone planctonique côtière, à changements rapides du milieu (apports des cours d'eau, remontées de vase profonde), de la zone du large, plus strictement pélagique, sans impuretés terrigènes et à courants verticaux rares. Pour autant que j'ai pu en juger, d'après l'effet sur le microplancton, la zone du large commence à 13 kilomètres des côtes à Monaco, vers 150 kilomètres au Sénégal, plus loin encore si les courants amènent de la vase ou des substances venant des fleuves.

Cycle au large: forme typique à plaques peu nombreuses (7 à 20), soudées entre elles en coque bien sphérique, assez rigide: c'est le type *Coccolithus fragilis* de Lohmann, coloré en brun-rouge foncé par ses deux plastes. Les flagelles, très longs, se cassent facilement, et il est très rare de ramener ce stade intact au laboratoire (1, Fig. 1).

Souvent, la cellule devient encore plus opaque, presque noire, à cause de la sécrétion d'un kyste calcaire (2), phase résistante entrevue par Lohmann (1921) mais non décrite jusqu'ici. La coque normale avec ses trémalithes (2 bis) se recouvre de prismes calcifiés serrés. Pareils kystes, de taille assez variable (7 à 60 μ), sont particulièrement communs dans les eaux très pauvres en phosphates et en plancton total, ce qui me fait supposer qu'il s'agit surtout d'une forme de résistance à la disette. En cas de changement brusque du milieu, le Flagellé réagirait plutôt par la production de spores internes (3), au nombre de 4 à 64. Ces spores, ovoïdes, ont une cuticule granuleuse, orangée, de nature inconnue, et ne sont libérées que par la putréfaction de la coque initiale, processus qui semble demander plusieurs jours au moins en vase clos à 20°. Dans des conditions assez spéciales, que nous chercherons à délimiter plus loin, la spore éclôt, donnant un jeune Flagellé (5) qui reviendra au stade 1.

En milieu favorable, ces petits Flagellés se divisent abondamment avant d'atteindre la taille "adulte", et constituent des amas volumineux (6), dépourvus de flagelles par suite de la cadence des divisions. Ces amas, souvent visibles à l'oeil nu, font de petits grains rouge-orangé dans l'eau des bouteilles, et permettent d'affirmer, dès la prise sur le bateau, qu'il y a de bonnes conditions de multiplication pour le *Coccolithus*.

Enfin, en Méditerranée, on trouve souvent au large, avec maximum vers 350 mètres de profondeur, des cellules vert-olive (7), à pores des trémalithes plus larges que dans *fragilis* normal. Il s'agit peut-être d'une espèce distincte inédite, mais ces éléments verts font éventuellement partie du cycle dans les eaux tyrrhéniennes?

Cycle côtier. Parmi les stades du large, seules les spores orangées,

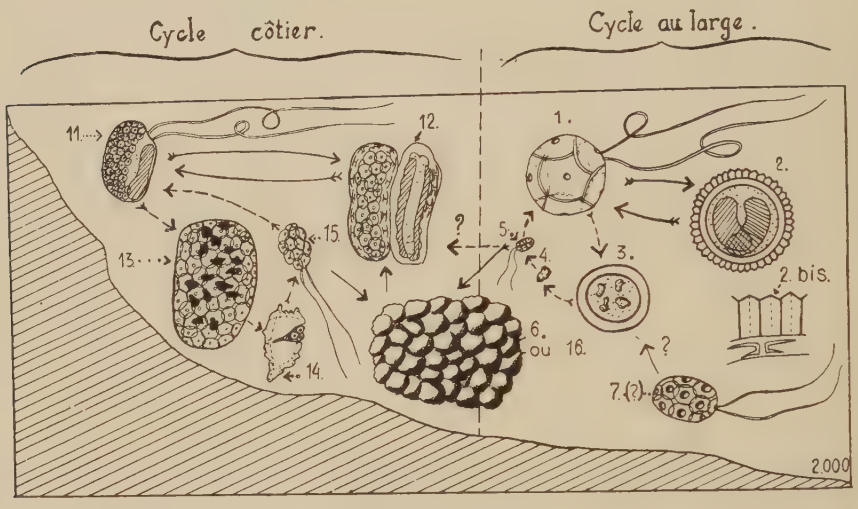

Figure 1. Schéma du cycle de *Coccolithus fragilis*. Les flèches en traits pleins indiquent les phases de division ou d'enkystement; les flèches en traits interrompus marquent les phases de sporulation ou de croissance:

1: adulte typique du large, à plaques soudées; — 2: son kyste calcifié, avec fragment de paroi plus grossie en 2 bis (montrant trois prismes calcaires et un trémalithe); — 3: formation de 4 spores internes orangées dans le stade 1; — 4: libération d'une spore (après pourriture de la coque gélatineuse); — 5: jeune Flagellé orangé, issu d'une spore du large et pouvant éventuellement(?) passer aux stades côtiers; — 6: amas de cellules sans flagelles, provenant de la division abondante du stade 5; — 7: cellule vert-olive, commune dans les eaux tyrrhéniennes (300 à 800 mètres à Monaco), et faisant peut-être partie du cycle profond de *C. fragilis* malgré ses pores plus larges.

11: stade côtier dominant, à plaques petites et non soudées entre elles; à droite, les plaques ne sont pas figurées, pour montrer le plaste brun-rouge; — 12: stade palmella, avec divisions abondantes sous coques gélifiées; dans la cellule de droite, on voit la coque (trois trémalithes seulement sont figurés), le protoplasme interne (ponctué) et deux plastes hachurés; — 13: gros individu côtier, tombé sur le fond, et ne contenant plus que 16 spores noires; — 14: éclosion d'une de ces spores, donnant un jeune Flagellé 15, semblable au stade 5 du large et pouvant aussi fournir des amas compacts (16).

Ce schéma concerne surtout le cycle en surface (0 à 50 mètres), les phénomènes profonds réclamant de nouvelles recherches.

petites et probablement moins denses, sont fréquentes près des côtes. Les cellules sphériques sont rares, les kystes encore plus, ces deux phases n'arrivant à Monaco et Alger qu'après les périodes de vent marin prolongé, toujours en faible densité (1 à 300 individus au litre). Au contraire, d'autres formes plus spéciales à la zone côtière (11 à 15) pullulent, jusqu'à 2 millions au litre près du Sénégal, à 600,000 en Méditerranée: une eau récoltée par le "Président Th. Tissier" au Sénégal était colorée en rouge par ces Protistes. L'adulte côtier est ovoïde, mou, car ses

petites plaques serrées ne sont pas soudées entre elles. Normalement à coque mince (11) il peut, surtout après dessalure légère des eaux, acquérir une paroi gélatineuse épaisse (12) et se diviser sous elle, fournissant des masses palmelloïdes encore plus grosses que les amas 6.

Ces deux stades (adulte normal et palmella), sont souvent bourrés de spores noires (13), semblables aux spores orangées du large, mais plus opaques. Elles sont la règle dans les grands individus de 60 à 120 μ, provenant vraisemblablement de la croissance des autres, et dont les coques abondent dans la vase du fond (13). On rencontre, surtout en automne, de telles spores en voie d'éclosion par déhiscence (14), libérant un jeune flagellé orangé (15) pratiquement identique au stade 5 du large, et pouvant aussi se diviser en amas sans flagelles (16).

Y a-t-il des intermédiaires entre les deux cycles, ou bien les phases du large représentent-elles une espèce à part? Seule la culture pourra trancher définitivement ce problème, mais j'ai vu fréquemment, à Monaco et Alger, des cas de transition très probables: passage entre la coque côtière à petites plaques et la coque du large sphérique, existence de trémalithes de grande taille dans certaines palmellas, etc. Seul le kyste calcaire semble bien particulier à la zone pélagique: sans doute, le milieu côtier trop variable et riche en détritus empêche sa formation.

En résumé, le *Coccolithus fragilis*, très difficile à conserver vivant au laboratoire, est extrêmement sensible aux variations du milieu. Il réagit à des conditions anormales: au large, par kystes ou spores orangées—près des côtes, par spores noires, probablement plus résistantes. Le stade palmella, surtout côtier, semble favorisé par une légère dessalure locale.

Malgré tout, ce Flagellé ne mérite guère son nom spécifique *fragilis:* par comparaison avec les formes voisines: *C. leptoporus* Murray, *C. tenuis* Kamptner, *C. oblongoporus* Schlauder, il se montre relativement plus robuste, ces autres espèces étant strictement pélagiques et fabriquant beaucoup moins souvent des spores et kystes.

4. Facteurs physico-chimiques du cycle de surface à Monaco. (Fig. 2).

L'étude de 96 échantillons d'eau à Monaco, pris à 6 km., 3 du rivage, par 450 mètres de fond, permet une reconstitution approchée du cycle côtier, en fonction des vents, pluies, salinités, températures, phosphates et nitrates, à 10 mètres de profondeur (48 prises) et 50 mètres (48 prises). Trois remarques préliminaires me paraissent indispensables:

a) Le pH et la teneur en oxygène ne furent pas mesurés. En Méditerranée profonde, leurs changements sont bien moins notables que dans les mers ouvertes: leur valeur moyenne se montre élevée, d'après l'expédition du "Thor", et convient très bien aux exigences des Flagellés calcaires, évaluées selon les résultats du "Meteor" dans l'Atlantique sud (1936).

b) L'emploi des données physico-chimiques doit varier suivant les saisons: à Monaco, en hiver, les courants verticaux dépendent surtout des différences de salinité — en été, ils sont plutôt déclanchés par les écarts de température entre surface et profondeurs. Le régime des vents joue son rôle maximum au printemps et en automne. De plus, les Protistes concurrents du *Coccolithus* ne sont pas les mêmes suivant l'époque: Diatomées en Juin, *Calyptrosphaera* en Mai, Schizophytes en automne, etc. . . . On ne pourra donc pas utiliser le même raisonnement pour toute l'année.

c) La masse principale du *C. fragilis* est représentée par les stades du large, vu l'énorme étendue marine peuplée par cette espèce jusqu'à 3,000 mètres et plus. Il est donc vraisemblable que le cycle au large, moins bien connu, est la vie normale du Protiste. Nous ignorons si les individus côtiers proviennent toute l'année d'une même souche, ou bien si des spores orangées venues du large peuvent éclore près des rivages et renouveler le stock local. Cette dernière hypothèse est la plus logique d'après mes observations: au printemps, après un vent du large prolongé, on voit pulluler à Monaco et Alger une forme de *C. fragilis* un peu spéciale, plus grosse et à pores plus dilatés. Ainsi, l'interprétation des agents physiques est rendue encore plus complexe, s'il y a des races différentes apportées de loin.

Compte tenu de ces multiples difficultés d'interprétation, voici les résultats les plus confirmés par la statistique des prises d'eau:

Le graphique 2 schématise les facteurs optimum de production pour deux catégories de stades de l'espèce:

a) Stades "adultes" actifs, c'est à dire les cellules ovoïdes (11, Fig. 1), et les palmellas (12), toutes deux capables de division fréquente (la nuit), et mesurant de 14 à 120 μ par individu. Leurs limites de pullulement sont indiquées en traits pleins sur la Fig. 2. Elles peuvent abonder en toutes saisons.

b) Jeunes Flagellés récemment éclos des spores: stades 5 et 15, Fig. 1. Ils ne dépassent pas 8 μ, et, jusqu'ici, il est impossible de reconnaître ceux provenant de spores du large orangées de ceux sortis des spores noires.

Les facteurs favorables à l'éclosion des spores se montrent assez différents des précédents (traits interrompus, Fig. 2), et beaucoup plus limités dans l'année, car l'optimum de température est, très nettement, compris entre 18° et 22°5. Il y a donc très peu de "jeunes" en hiver et en été par rapport aux autres stades, et relativement beaucoup de spores non écloses. Celà est encore plus clair si, au lieu de compter isolément les jeunes, on calcule le rapport suivant au litre:

$$\frac{\text{Nombre total de jeunes Flagellés libres}}{\text{Nombre total de spores non écloses}}$$

Ce rapport varie de zéro à 340 %: dans quelques prises, surtout en Novembre, il y a donc 3·4 fois plus d'éclosions que de spores intactes.

Il ne reste plus qu'à examiner l'action des principaux agents du

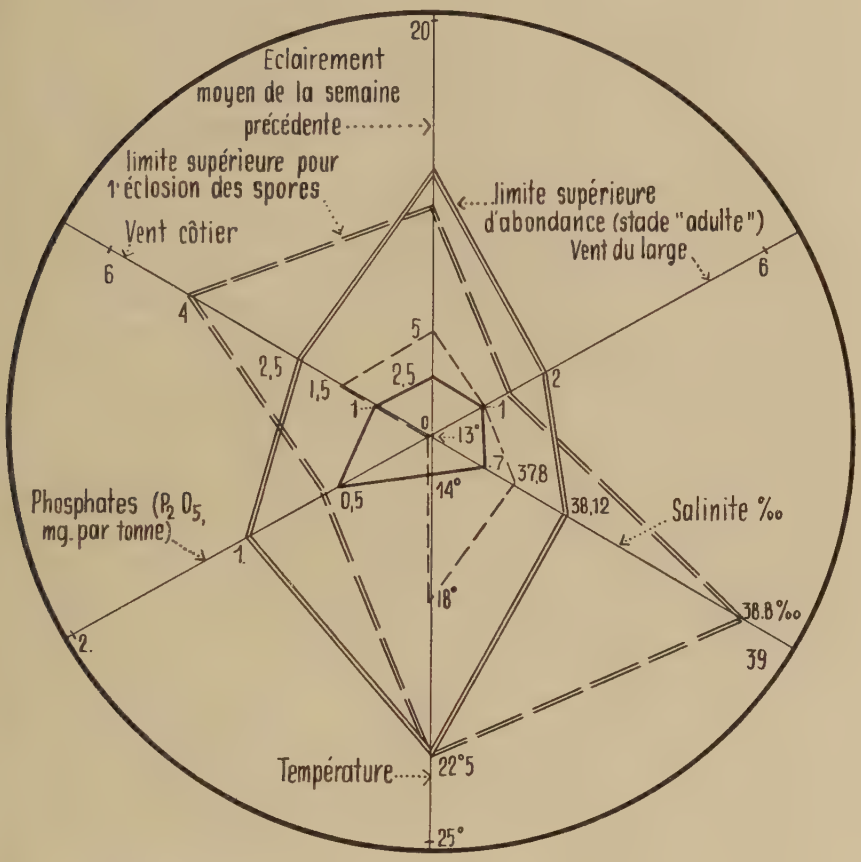

Figure 2. — Diagramme résumant les conditions optima pour la multiplication du *Coccolithus fragilis* à Monaco (eaux côtières de 1938, à 10 mètres de profondeur): Le cercle périphérique correspond au milieu limite annuel (maxima des facteurs physico-chimiques) sauf pour le vent du large qui peut atteindre 14 mètres seconde de moyenne en Décembre. *L'éclairement* (en haut) est évalué de 1 à 20,1 étant l'éclairement moyen durant la semaine la moins ensoleillée de Décembre, et 20 celui de la semaine la plus ensoleillée de Juin. Les *vents* sont calculés aussi pour la semaine précédant chaque prise d'eau: chaque chiffre correspond au vent moyen, côtier ou du large, exprimé en mètres par seconde. Les *phosphates* sont en milligrammes P_2O_5 par mètre-cube d'eau de mer, enfin la *température* (au bas) est en degrés centigrades. En traits pleins doubles: limite supérieure de pullulement du stade adulte et des palmellas (11 et 12 de la Fig. 1) — en traits pleins simples: limites inférieures de la même production. — En traits doubles interrompus: limite supérieure pour l'éclosion des spores — en traits simples interrompus: limite inférieure d'éclosion massive.

milieu sur ces stades actifs: la considération des spores et kystes serait moins significative, car on ne sait pas si tous ces stades opaques de résistance sont encore capables d'éclosion.

1. Les vents. Ils influent sur la température de l'eau, sur les

courants (remontée d'eau profonde ou apports du large), donc, indirectement, sur les sels nutritifs et la composition du plancton:

Divers essais statistiques m'ont amené à calculer le v e n t m o y e n durant la semaine qui précède chaque prise: un vent de courte durée, même fort, semble avoir beaucoup moins d'action sur la fertilité que cette résultante de plusieurs jours. Il faut, naturellement, séparer deux sortes de vents:

Le vent côtier moyen varie de 0 à 6 mètres-seconde suivant la semaine étudiée. Le pullulement des cellules "adultes" se fait par 1 mètre à 2·5 m., c'est à dire une vitesse suffisante pour remonter du fond des substances nutritives, sans modifier trop rapidement le milieu. L'éclosion des spores est favorisée par des vents côtiers plus intenses.

Le vent du large, dominant à Monaco, va de 0 à 14 mètres de moyenne hebdomadaire; il est généralement moins favorable que le précédent, mais *C. fragilis* le tolère jusqu'à 2 mètres seconde de moyenne.

2. E c l a i r e m e n t. Pour chaque semaine précédant une prise d'eau, l'éclairement moyen est évalué, d'après le nombre d'heures d'insolation et l'éclairement à 10 mètres de profondeur, mesuré par cellule L. M. T., soit par temps couvert, soit en plein soleil. On trouve ainsi un éclairement moyen h e b d o m a d a i r e minimum en Décembre, que nous prendrons égal à 1 par convention, et maximum en Juin, environ 20 fois plus grand. Bien entendu, certains jours de Juin, il y a cent fois plus d'énergie lumineuse qu'en hiver, mais l'effet sur plusieurs jours ne dépasse pas 20 fois celui de la période la plus défavorisée.

Coccolithus fragilis a son optimum par éclairement moyen, entre 2·5 et 13 fois le minimum. L'éclosion des spores se placerait entre des limites plus étroites (5 et 11), mais il s'agit peut-être d'une simple coïncidence avec d'autres facteurs, car les fortes luminosités concordent dans l'année avec des températures défavorables à ce phénomène.

3. T e m p é r a t u r e d e l ' e a u. Elle varie de 13° à 25°C. La production de cellules du *Coccolithus* est toujours faible au dessous de 14° (pullulement de Diatomées et Schizophytes), comme au dessus de 22·5° (abondance de Péridiniens et de *Calyptrosphaera*). Ce sont donc des organismes concurrents qui nuisent ici aux *Coccolithus,* plus que la température elle même, car, dans l'Atlantique, ils peuvent prospérer de 11 à 34°. Par contre, les spores éclosent surtout entre 18 et 23°.

4. P l u i e s e t s a l i n i t é s. La salinité passe de 37·6 à 39 ‰, et l'on trouve le *C. fragilis* dans tout cet intervalle. Mais, au dessous de 37·7 et au dessus de 38·8, l'espèce est surtout représentée par des spores inertes. Entre ces valeurs, il y a éclosion facile des spores: toutefois, l'état "adulte" n'abonde que sous des salinités plus définies: 37·7 à 38·12. Enfin, l'année 1938 montrait six grandes poussées du stade gélatineux palmelloïde, toutes précédées, huit à quinze jours auparavant, d'une dessalure légère par pluies locales ou crues de torrents.

Ces faits, valables pour les eaux superficielles, ne ressortent plus à partir de 200 mètres de profondeur: là, notre Flagellé pullule jusqu'à 39 ‰ de salinité, à l'exception des palmellas, qui semblent nécessiter

encore une dessalure notable. C'est un des arguments déjà invoqués pour supposer l'existence de "races profondes", différentes physiologiquement de celle de surface.

5. Phosphates et nitrates dissous. La teneur en P_2O_5 soluble, relativement très basse, est de 0 à 2 milligrammes par mètre cube d'eau en surface, de 0 à 5 dans les couches profondes. Dans 8 prises d'eau sur 48, il n'y a pas trace de phosphates, et pas davantage de poussée numérique des Flagellés: celle-ci a lieu en conditions moyennes, pour 0·5 à 1 milligramme de P_2O_5. Au delà de 1 (il y a 2 milligrammes dans 5 prises d'eau printanières), d'autres Protistes comme les Diatomées, les Chlamydomonadines, l'emportent en volume.

Conclusion (appuyée sur les faits de Monaco, Banyuls et Alger): les *Coccolithus* de surface ont très probablement besoin de phosphates, mais les utilisent assez lentement, si bien que, avec sels nutritifs abondants, des êtres à métabolisme et mitoses plus rapides prennent la dominance locale. Les Flagellés calcaires profonds présentent *a priori* une physiologie distincte, et j'ai vu de jeunes *Coccolithus* abonder sur des carapaces de Copépodes en décomposition: ils mèneraient alors une existence saprophyte?

Les variations des nitrates dissous ont, en Méditerranée côtière, beaucoup moins d'influence sur le cycle. En effet, leur teneur par mètre cube d'eau est exceptionnellement élevée (15 à 600 milligrammes, richesse surprenante, dûe sans doute aux sels dissous par les torrents régionaux). Une seule fois, en 1938, il n'y a pas eu trace de nitrates décelables par le réactif à la strychnine réduite: ce jour là (30 Mai), *C. fragilis* était représenté uniquement par des stades résistants, spores et kystes.

Donc, l'espèce utilise les nitrates, mais leur proportion habituelle donnerait un rapport $\frac{\text{Azote}}{\text{Phosphore}}$ (atomes-milligrammes) égal à 300; six fois plus grand que dans les mers ouvertes et la Méditerranée centrale! Cette anomalie du rapport des éléments nutritifs entraîne sans doute, en Méditerranée côtière, une biologie spéciale des Bactéries et des êtres autotrophes.

6. Conclusion. Le *Coccolithus fragilis,* dominant fréquemment sur les autres Protistes planctoniques, est adapté fort bien aux conditions moyennes de la Méditerranée. Près de Monaco, ses exigences de milieu correspondent à 36 prises d'eau favorables sur 48, soit environ les $^3/_4$ de l'année. Seuls des vents, pluies ou températures extrêmes limitent sa production, mais ce Flagellé est toujours présent dans les eaux, tout au moins sous forme de stades résistants: spores et kystes. L'éclosion des spores est soumise à des conditions assez spéciales: assez indifférent aux phosphates et à la salinité, ce phénomène est, quant à l'éclairement et aux températures, plus étroitement limité que la multiplication banale des cellules adultes. Il s'agit là de la biologie en surface, celle des eaux profondes réclamant de nouvelles recherches.

Résumé.

1. The Calcio-flagellate, *Coccolithus fragilis*, is the commonest member of the nanoplankton in several warm seas, western Mediterranean, eastern Atlantic, etc., from the surface to 3,000 metres at least. At Monaco, the mean annual volume of this species amounts to 36 % of the total volume of Protists, to 80 % at Algiers.

About 2,000 water samples, from Monaco, Banyuls, Algiers, Biarritz, and Senegal, have permitted a first re-constitution of the life-cycle, partly hypothetic, because *Coccolithus* is very difficult to keep in cultures.

2. The physico-chemical data, measured at Monaco, are: — wind and sunlight (mean per week), rainfall, temperature, salinity, phosphates and nitrates. As a rule, in the Mediterranean, the values of pH and oxygen content are fairly high and favour the development of *Coccolithus*.

3. Two kinds of cycle may be distinguished: — the coastal cycle, in polluted or variable waters, and the pelagic cycle, beginning, at Monaco, at 13 or 14 kilometres from the seashore. Downwards, specialized cycles or "physiological races" are probably present in deep waters (from 200 to 2,000 metres). The pelagic cycle of the Flagellate is fairly simple, with cysts, spores, and assemblies of young individuals issued from spores (Fig. 1, 6). In the coastal zone, cysts are very rare, the spores are black, and the free *Coccolithus* is quite different from the pelagic type — softer and able to produce palmellae. Resting stages occurring very easily, *C. fragilis* is always common in the water, at least in spore or cyst form.

4. This species is well adapted to the ordinary environment in warm seas; three out of four water samples are favourable to local production. Figure 2 summarizes the conditions at Monaco. Only too extreme conditions of wind, sunlight, salinity, etc. seem to be unfavourable. The "adult" stage may swarm from 14° to 22·5°C., and probably use phosphates and nitrates at the surface layers, decaying matter or bacteria in great depths. The hatching of young Flagellates from spores needs more restricted and different conditions — 18 to 22°, coastal wind prevailing, but not strong enough to bring phosphates and bottom slime upward.

Coccolithus fragilis is an important, though not essential, food of the zooplankton. Copepods and various larvae probably digest all the stages of the Protist. Therefore the above study may add to our understanding of the fertility of warm seas.

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Quelques Considérations sur la Composition des Bancs de Harengs exploités par les Chalutiers Belges sur le Fladen et le Gut au cours de l'année 1946.

Par

Ch. Gilis.

Le matériel étudié, prélevé en août et septembre 1946, comprend 14 séries d'échantillonage, qui comptent au total 643 harengs: 9 séries ou 398 harengs ont le Fladen pour origine; les 5 autres séries ou 245 individus, le Gut.

Les caractères biologiques de ce matériel sont publiés *in extenso* dans les *Annales Biologiques* du Conseil, Vol. III, — 1946.

Nos investigations personnelles sur les concentrations de harengs sur le Fladen et le Gut en 1946, ne constituent encore qu'une première reconnaissance sur un terrain tout nouveau pour nous.

Néanmoins l'analyse des observations faites en août et septembre 1946, nous permet déjà de soulever certaines questions sur la composition des bancs de harengs rencontrés sur le Fladen et le Gut:

1. Les harengs capturés successivement dans ces deux régions sont-ils les mêmes?
2. À quels types de harengs appartiennent-ils?
3. La présence de tous les stades de maturité dans une concentration exploitée dans les mêmes conditions et à la même époque, n'indique-t-elle pas qu'elle est constituée par des Harengs de Printemps et des Harengs d'Automne?

En comparant les valeurs moyennes observées sur le tableau récapitulatif, ci-après, nous croyons trouver la réponse à la première question: les harengs capturés par nos pêcheurs dans les deux régions précitées se rapprochent de très près.

En effet, tous les caractères biologiques observés pour les deux régions séparément ne s'écartent guère ou peu, ce qui indiquerait que les bancs de harengs rencontrés sur le Fladen et le Gut sont identiques.

Récapitulation des valeurs observées sur la population de harengs du Fladen et du Gut en 1946.

Observations	Fladen	Gut	Fladen + Gut
Longueur moyenne en cm	26·8	26·4	26·7
Taille : mode	26	27	27
Stades des gonades : mode	V	V	V
Graisse mésentérique : mode	1	0	1
Classes de recrutement : mode	1940	1940	1940
Tailles moyennes des harengs nés en 1943	22·9	22·3	22·5
" " " " " " 1942	25·0	25·3	25·2
" " " " " " 1941	26·1	26·6	26·3
" " " " " " 1940	26·9	26·9	26·9
" " " " " " 1939	27·5	27·5	27·5
Valeur moyenne de L1 des harengs nés en 1943	11·9	11·2	11·4
" " " " " " " " 1942	11·8	11·9	11·9
" " " " " " " " 1941	12·2	12·3	12·3
" " " " " " " " 1940	12·0	11·9	12·0
" " " " " " " " 1939	12·9	13·0	13·0
" " " " " " " " 1938	11·4	11·9	11·5
" " " " " " " " 1937	11·3	10·8	11·2
" " " " " " " " 1936	10·7	10·3	10·6
" " " " calculée sur tout le lot	11·8	11·9	11·8
Nombre de vertèbres : mode	57	56	56
moyenne	56·47	56·45	56·46
Nombre de vertèbres cervicales : mode	24	24	24
moyenne	23·85	23·77	23·82
Nombre d'estomacs avec contenu	23	64	87
Répartition pour 100	5·8	26·1	13·5

L'élucidation de la deuxième question, celle de savoir de quels types de harengs ils se rapprochent, paraît plus ardue. Pour le moment nous n'avons que la moyenne vertébrale et la valeur de L1 qui peuvent nous fournir une indication à ce sujet.

La moyenne vertébrale observée, soit 56·46, est légèrement oligospondylique (<56·50), indice qui caractérise les harengs du type de la Mer du Nord.

La valeur moyenne déterminée pour L1, soit 118 mm., est remarquablement supérieure à celles qui ont été déterminées jusqu'ici pour le type de la Mer du Nord.

Ainsi H o d g s o n obtint 80 mm. pour les harengs de la côte est de l'Angleterre. G i l s o n 100 mm. (hiver 1930—31) et G i l i s 109 mm. (hiver 1945—46), pour la concentration de harengs guais qui fréquentent chaque hiver les côtes françaises et belges. Toutefois cette concentration constitue un mélange de harengs du type Mer du Nord et du type Manche. Ce qui explique que la valeur de L1 est remarquablement supérieure à celle du type pur de la Mer du Nord. On y observe d'ail-

leurs également une moyenne vertébrale intermédiaire entre celle du type Nord et du type Manche.

Au stade où se trouvent nos recherches sur les harengs du Fladen et du Gut, il nous est donc impossible de nous prononcer catégoriquement.

D'une part les biométriciens considèrent le nombre de vertèbres comme le caractère le plus probant étant donné qu'il est absolument net et facile à déterminer.

D'autre part les mensurations de L1 présentent souvent de grosses difficultés et des erreurs ne sont pas exclues. Aussi cette étude est moins poursuivie et par conséquent moins avancée que celle des vertèbres.

En attendant les résultats des recherches continues, qui peuvent s'étendre sur un grand nombre d'années, nous croyons pouvoir conclure que la majeure partie des harengs pêchés par les pêcheurs belges en 1946, sur le Fladen et le Gut, se rattachent plutôt à la population de la Mer du Nord qu'à une autre.

Reste le troisième problème, à savoir, si les concentrations de harengs au Fladen et au Gut ne constituent pas un mélange de Harengs de Printemps et de Harengs d'Automne.

A l'exemple de F u r n e s t i n, qui a résolu ce problème affirmativement, nous avons scindé notre matériel d'étude en trois groupes:

1r groupe: harengs dont le stade de maturité est peu avancé et qui sont supposés avoir reproduit au cours de la première moitié de l'année (stades I—II et III).

2ème groupe: harengs dont la maturité atteint le stade IV et qui peuvent appartenir soit aux Harengs de Printemps soit aux Harengs d'Automne (F u r n e s t i n a éliminé ce stade).

3ème groupe: harengs dont les produits génitaux sont déjà fort développés (stades V, VI), les harengs qui en ont déjà commencé l'évacuation ou dont les gonades sont déjà vides (stades VII et VIII—II).

Nous croyons que c'est encore le caractère vertébral de chacun de ces 3 groupes qui peut le mieux nous renseigner à ce sujet.

Fréquence de chaque nombre de vertèbres observé pour chaque groupe séparément:répartition pour 100 et moyennes.

Groupes	Nombre de vertèbres					Nombre	Mode	Moyenne vertébrale
	54	55	56	57	58			
I (St. I, II, III)	—	2·8	40·3	51·4	5·5	72	57	56·60
II (St. IV)	0·8	3·3	51·6	37·7	6·6	122	56	56·46
III (St. V à VIII)	0·7	5·8	46·5	42·3	4·7	449	56	56·44

En effet les moyennes vertébrales déterminées pour les trois groupes séparément donnent une moyenne vertébrale (56·60) nettement polyspondylique pour les harengs du groupe I, tandis que l'indice vertébrale (56·46 et 56·44) des groupes II et III est légèrement oligospondylique.

Il est donc probable que les harengs du groupe I appartiennent aux Harengs de Printemps, tandis que ceux des groupes II et III peuvent être considérés comme étant des Harengs d'Automne.

Enfin, il est intéressant de noter que peu d'estomacs contenaient de la nourriture, ce qui indiquerait qu'à ce moment la majeure partie de ces harengs était à son stade de prématuration.

Reste à déceler l'endroit où ces harengs passent leur période d'alimentation, laquelle se situe probablement d'avril à juillet. Une étude approfondie de toutes les concentrations de harengs exploitées pendant la période d'alimentation, au point de vue des différentes populations qui peuvent se mêler dans une même région, est hautement recommandable, car elle ne manquera pas de fournir des indications très appréciables sur le cycle migratoire des harengs.

Ainsi on pourrait espérer de pouvoir décrire un jour le *curriculum vitae* des harengs qui chaque automne apparaissent en bancs serrés au large de la côte est de l'Angleterre, où ils ne font que passer pour se diriger vers l'extrême sud de la Mer du Nord. C'est dans cette région que l'on rencontre, à distance de la côte, à partir de novembre, une forte concentration de harengs en pleine période de reproduction. A partir de fin novembre ils apparaissent à l'état guais à proximité des côtes françaises et belges où ils passent une période de convalescence. Fin février ou au commencement de mars les harengs quittent cette bande littorale et à partir de ce moment on perd le fil de leur cycle migratoire.

S'ils nous reviennent après une année ou s'il leur arrive de frayer ailleurs est encore un point douteux.

On conçoit donc combien il est désirable dans l'intérêt de la pêcherie du hareng, qui dans la Mer du Nord constitue de loin l'exploitation la plus lucrative, que l'étude de cet important clupéide soit poussée activement et simultanément avec tous les experts des pays riverains de la Mer du Nord.

Herring Fishing with the Echometer.

By

Ronald Balls.

Introduction.

THE seven years' experience with the Echometer in herring fishing, on which this account is based, was gained, not in a research vessel, but under ordinary commercial drifter conditions. My idea was to find out whether or not the machine could increase catching efficiency; therefore my working notes had to be absolutely unbiassed, and whereas a properly organized experiment in this field of research would have had the advantage of more copious and detailed notes, this is perhaps balanced in my amateur attempt by keenness of observation and the length of time covered.

A fisherman's saying during the pre-war depression was that any fool can catch fish but it takes a wise man to sell them. But herring are not so easily caught that anything to help that process should not be welcomed.

It was through a hint from Dr. H o d g s o n of the Fisheries Laboratory, Lowestoft, that I first became interested in the idea of using the echo-sounder for spotting herring shoals, and in 1933 I fitted an instrument in my drifter "Violet and Rose" YH. 757, where it was used with varying success from that date until 1939. My thanks are due to him for his kind interest and help in preparing this account.

The two outstanding features shown by an examination of the "Violet and Rose" results are: (i) the steadily increasing efficiency in the use of the Echometer for locating herring during the successive summer seasons; and (ii) the almost consistent failure of the machine in this respect of the East Anglian autumn herring fishery in which the concentration of fish is usually much greater. These conclusions, being contradictory, suggest that some change in local conditions on the two fishing grounds is the cause.

The method of using the sounder was exactly the same in both regions, of course, although at times the press of boats at Yarmouth was

a handicap. After 1935, however, the Echometer was seldom used for choosing a fishing position at Yarmouth. It was only watched for the "swim" of herring at suitable times.

After a brief description of the Marconi Echometer, Type 424, which was used throughout, a more detailed account of some actual nights' fishing and a discussion of the summer results are followed by an attempt to explain, as far as possible, the failure of the instrument during the autumn.

Readers are asked to remember that the writer is not a scientist but a fisherman whose reasoning may be less concise than that of the specially trained fishery research worker.

How the Echo-Sounder Works.

The Echometer used in the "Violet and Rose" works in this way: A copper plate in the ship's bottom vibrates, sending down waves which are thrown back by the sea bed. This echo is received, amplified, and

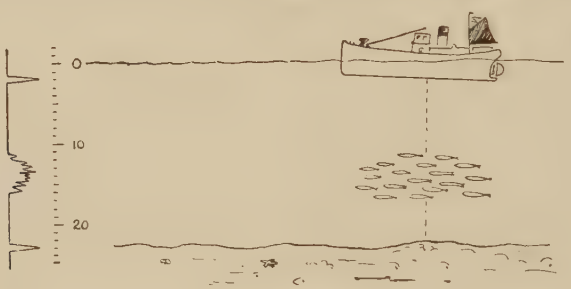

Figure 1. Showing how watching the Echometer is like looking at the water between the ship and the sea-bed.

shown as a sharp peak on a line of light that runs across the fathom scale of the instrument which is fitted in the wheelhouse. Any object which is suspended in the path of the downward waves will reflect some of them to show a subsidiary peak representing the depth of the object. A shoal of herring at, say, ten fathoms will therefore cause an echo or peak at ten fathoms on the scale, while the waves that get through the shoal will continue to the bottom and return to give the depth peak as usual. The drawings show the transmission peak as well as the depth peak.

Looking at the spotlight line between the transmission and depth peaks is like looking into the water between the ship's bottom and the sea-bed, and this gives rise to the somewhat misleading term "seeing the herring".

The "424" makes 45 accurate visible soundings a minute, but in fish-echo work this visual method has one drawback in not leaving a permanent record, so that of thousands of fish-echoes seen in "Violet and Rose" there is not one actual imprint to show. My figures and

drawings come from notes taken daily of observations during the fishing seasons.

In an official fish-echo experiment, made in 1935 at the Lofoten cod fishery, an echo-sounder of the recording type was used. This machine marks the depths and echo on a roll of paper which can be kept for future reference.

The fishery research vessel "Johan Hjort" steamed over the grounds plotting the extent and depth of the fish concentration by means of the sounding machine. She was boarded daily by the fishermen who set their nets and lines according to the echo diagram shown them by the scientists and, to quote the official account, "many reports of good results came from boats that did this".

Norway does not neglect her fisheries, to say the least of it, and it is probable that further work in this direction has been done, quite possibly with herring.

I have no experience of the recording type of echo-sounder. For use in herring fishing it could hardly be better than the Echometer's visual method, which seems the nearest possible thing to actually seeing the fish.

But for research purposes the machine leaving a permanent picture would of course be invaluable and, had one been used in "Violet and Rose", the echoes seen in 400 nights of summer fishings alone would have provided plenty of material for those interested in inspecting it.

Success in Summer.

In drift-net fishing it is considered necessary for the gear to be in the sea by dusk. Shooting an average fleet of 91 nets takes about half an hour. They are paid over the side as the drifter moves slowly before the wind and form a vertical wall of netting a mile and three-quarters long and fourteen yards deep in the water when the ship finally swings round to leeward of them. Once shot, there is no visible movement of nets or ship but both are drifted over the ground by the tide. The distance drifted, usually called the "drive", may be anything from 6 miles (or less) during neaps and in Shields waters, to 12 miles at spring tides on East Anglian grounds.

Now, given equality in the number and efficiency of nets, the most important factor governing success in herring fishing is choice of position, that is, deciding where exactly to shoot the nets. So that to be of practical use, the Echometer must be able to influence this choice by indicating herring shoals during daylight. (On more than one occasion in "Violet and Rose" we caught herring by shooting after locating them by echo in the dark, but this is not convenient where boats are already fishing.)

After a time the following routine was adopted: We would leave harbour late as possible with a certain fishing ground in view. At about ten miles off, usually, the sounder was switched on and then watched

continuously until herring were "seen" or, failing that, until we began to shoot the nets. A more natural procedure would have been to begin early to allow more time for searching, but it soon became apparent that this lateness was an essential feature of herring location by echo.

Spells at the spotlight were taken by myself and the men who happened to be on watch. This can be a somewhat tedious business but the machine was conveniently placed beside the steering wheel where one could sit watching it in reasonable comfort. The first feeling of strain caused by looking for something that was not there was soon forgotten when it was found that the echoes, when they did appear, were quite easily recognized. Such was the crew's interest and, later, their faith in the Echometer that I never lacked a keen observer to take my place.

Some of these men had sailed with me for ten years, and would handle a Plankton Indicator with the same professional discernment as

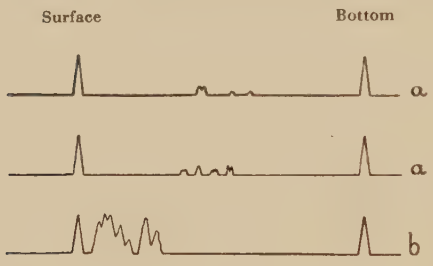

Figure 2.
(a) Types of small echoes seen at North Shields during May and June.
(b) Echoes often seen at night after shooting the nets where the a-type echoes were seen.

they mended or shot a net. But they still maintained a chilly silence at most "scientific stuff" I mentioned. And it was a source of secret amusement and some wonder to see one of them calmly watching the sounder while I steered. He would talk or fill and light his pipe without missing a beat of the spotlight until, finally, if a shoal was located, he would exclaim with satisfaction "Here they are!" and begin counting off the soundings all the time the echo was showing.

During May and June 1933 the only echoes observed in daylight were like those shown in Figure 2(a) — small separate peaks at various depths, sometimes showing only once, sometimes repeated for a number of soundings. Figure 2(b) shows the kind of echoes usually seen at night during those months. These were sometimes seen when no peaks had been seen before the nets were shot, but they were always seen if the nets had been shot where small signs of fish had been observed.

The results of shooting the nets where small echoes were seen were not large catches. In the two years 1933 and 1934, 36 shots are listed giving an average catch of 10 crans, the highest being one of 35 crans. Such echoes as are shown in Figure 2(a) seem to represent a fairly thin shoal of herring and they were seen mainly on the Shields grounds in the months of May and June when the herring are feeding. The shoals of small immature herring here sometimes provide a fairly heavy fishing,

but generally speaking shots of 15 or 20 crans are considered to be good at this time of year. (Small echoes seen after mid-July were mostly single peaks at, or very near to, the bottom.)

In 1936, 1937, and 1938 the inshore Shields grounds, being usually barren, were seldom fished until July by "Violet and Rose", long "icing" trips to the Scottish waters being made instead.

A point worth mentioning here is the long duration of the echoes shown in Figure 2(b), seen after dark when the nets had been shot after the observation of small signs in May and June. Usually showing at from 2 to 12 fathoms, they persisted for periods of between one and two hours on some nights, suggesting a protracted swim by these half-grown feeding fish.

The Echometer was studied at frequent intervals during the night by myself or other members of the crew, but after 1934 no record was made of echoes seen after shooting.

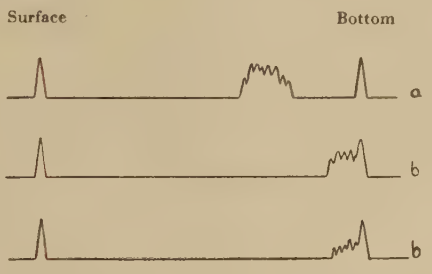

Figure 3.
(a) Typical echoes seen at North Shields.
(b) Echoes from fish massed at bottom.

August 1933 was a more successful month. Echoes as shown in Figure 3 were seen in daylight on five occasions and on shooting with these as guides, good results were obtained, with one night as an exception. The average catch for these five shots was 27 crans. The lowest catch, the exception already mentioned, was on the 25th of the month, and on this occasion a calm, accompanied by a very light fishing generally, was recorded.

Here is a case typical of the five shots in August. On the 22nd, "Violet and Rose" ran for six hours NE. by E. from the Tyne and came to 38 fathoms on the North-East Bank. (Fishermen usually refer to their locations in terms of the depth of water.) At about 8·30 p.m. there appeared at 27 fathoms on the Echometer scale a decided echo, taking the form of a jagged bend in the spotlight line, about eight fathoms wide and quite as prominent as the depth peak. It was repeated eight times.

The ship's speed at that time was 8 knots, which means that she must have moved fifteen feet through the water between each sounding, so, if the echoes were from herring, the shoal must have been about 100 feet long and some 40 feet in depth. "Violet and Rose's" head was turned into the light north-west wind with the intention of shooting back over that position, and after two or three minutes on this course

the spotlight arched again in a similar way — this time at 25 fathoms for six consecutive soundings.

Half a fleet of nets' length further to windward was the "Ocean Retriever" just swinging head to wind after shooting, and from here our nets were shot south-eastwards, back over the ground just searched. The catch next morning was 40 crans, while "Ocean Retriever" got only 12 crans from the first quarter of her nets, the remainder being blank. A feature of this night was the absence of echoes after dark. The machine was not kept going for the whole of the "drift-watch" but frequent periods of looking produced no signs at all. This experience, being contrary to that of the previous months, seemed to indicate a swim of short duration. A discussion of the swim comes later.

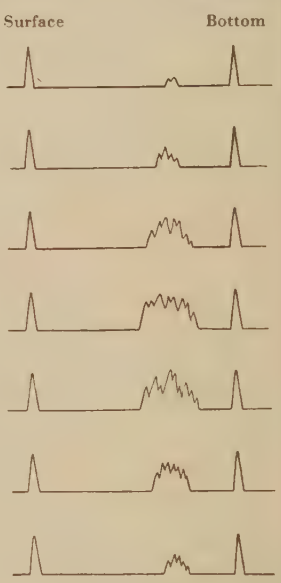

Figure 4.
Seven consecutive soundings while steaming showing echoes from a herring shoal 90 feet in length.

This shot may be taken as a case of Echometer fishing *par excellence* for the choice of position was entirely decided by the instrument, and without it "Violet and Rose" would almost certainly have shot somewhere else. In the list of echo-shots given there are 22 such occasions with a result of 30 crans or over.

No attempt is made here to estimate the actual commercial gain to "Violet and Rose" by the use of the echo-sounder. It would appear that on any given night's fishing where echoes were the only guide to position, the gain or loss would be that proportion of the catch above or below the average catch of all boats fishing the port, and in the 57 shots listed the nett gain, if any, would be the difference between the sums of the gains and losses. Against this, however, should also be placed the losses incurred on the nights when the Echometer was used and no echoes seen. The machine was used every night in all summer seasons with the exception of a few each year when the weather was too bad for the effective observation of the spot-light.

On one occasion in 1933 "Violet and Rose" left Shields with ice on board with the intention of proceeding further north if the inshore grounds yielded no herring that night. Because no echoes were seen where the fleet was shot I decided to carry on, without shooting, to the Peterhead grounds, but nevertheless a good fishing was landed by he Shields boats next day.

There is no way of arriving at the loss in this case. I am sure it was considerable. Possibly there were others like it but certainly not after 1934 when the first, and most important, complication in echo-fishing — that absence of echoes does not necessarily mean absence of herring — was definitely exposed.

On the credit side must be recorded the night of 6th July 1937. That day saw a fairly heavy fishing at Shields. The only ground fished was 55 miles NNE. and prices were high.

"Violet and Rose" landed a good shot and left harbour at about 3·0 p.m. with the last few boats which were, of course, hurrying back to the same fishing ground. At 8·0 p.m. I had just taken over the wheel and was watching the Echometer for the Farne Deep, which at 40 miles gives a useful check on position, when there came in front of the depth-peak an echo 3 fathoms wide, repeated three times (Fig. 3(b)).

I swung the ship about, and then turned north-north-eastward again over roughly the same ground where I saw a slightly smaller echo, only once. The nets were shot here at 39 miles, while the rest of the drifters continued to tne further ground. The catch was 60 crans. At the 55 miles ground the boats drew blank, a frequent occurrence on the night after a heavy swim, and the gain here is probably the full value of the shot, which realized £177. During the later years a few cases were experienced like this one, which is mentioned particularly to show my faith in the Echometer during summer.

Lists of individual shots were compiled from the contents of my diaries kept during the five seasons 1933 to 1937. Unfortunately those for 1936, 1938, and 1939 were lost when changing from "Violet and Rose" to another ship in 1940, but the results for 1936 had been summarized and were included in the total shots. The year 1936 was a shorter season during which the ship fished for only six weeks from Peterhead. This also happened in 1933. 1938 was very similar to 1937 with very good results in July and August, but 1939 was a somewhat less successful season.

To make this table of average catches[1]) a list was taken of all shots when the Echometer was used, omitting a few that did not seem to be a fair test. Nights when fishing position was decided by the echoes seen were called "shots with echoes" and those when no echoes were seen, before shooting, called "shots without echoes". The average for the shots with echoes was invariably the higher, and after 1934 it increased from year to year. From the totals it was seen that on 105 nights when the Echometer was the guide to position, the average catch was 20·8 crans — $2^1/_2$ times greater than the average (8·1 crans) for 294 nights when no echoes were seen.

It should be mentioned that these figures are probably biased against the Echometer by the use in May, June, and July of the Plankton Indicator. This is an instrument introduced by Professor A. C. Hardy, of Hull (now Professor of Zoology, Oxford), to enable drifters to sample the plankton content of the water in various places before shooting their nets. It has been used effectively in "Violet and Rose" to find favourable herring food during the feeding months and can also be

[1]) For the sake of economy, the detailed tables are not published here, but anyone who wishes to inspect them can do so on application to me.

useful in showing the presence of dense phytoplankton masses which the herring are known to dislike.

To avoid complication, figures showing the usefulness of the Plankton Indicator are not given, but an instance is one shot of 70 crans in the 65 shots without echoes in 1933. On this night the choice of fishing grounds was absolutely guided by the Indicator showing good, clean Calanus (the chief food of the herring) after towing through a wide area of phytoplankton, and the resulting 70 cran catch raises the average by over one cran.

Figures alone are perhaps inadequate to show the various impressions caused by the years of using the Echometer. Research was not the primary consideration and in competitive fishing mistakes could be very costly. Especially baffling was the fact that there might be plenty of herring where no echoes were seen; our methods had to be modified accordingly.

It was found that echoes were rarely seen on bright evenings, even when the usual herrings signs such as birds, whales, or favourable plankton were good. On dull days the reverse was the case and for this reason the time of searching was delayed as much as possible.

There was, however, a period during each summer season when conditions were ideal for successful echo-fishing. This was usually in the months of July and August; just why is not yet apparent, but it is significant that heavier shoals of more mature herring normally appear on the Shields grounds at that time.

Some other aspects of Echometer fishing are omitted but enough has been said to show, with a study of the figures and tables, that this new method of locating herring can be quite effective in summer. Now for the reverse side of the picture.

Autumn Failure.

The natural assumption that the Echometer would be more effective with the greater masses of herring off East Anglia is definitely wrong, for in not one of the seven years has it been found consistently useful in locating shoals, though, of course, its aid as a ready and accurate depth-finder remains constant. Quite a number of echoes were seen, but the cases where choice of berth (fishing position) was decided by them are so few that no figures are given.

Figure 5 (a) shows an echo seen just south of the Hearty Knoll off Yarmouth on 26th October 1937 while shooting at mid-day. With slight variation, it persisted for the length of seven nets — about 730 feet — so we were shooting over an area of almost "solid" herring, yet the depth peak was quite visible. My diary entry for the next day says: "125 crans at 30/6. 30 nets lost with herring".

It may be rightly said in this case that the Echometer warning should have prevented the loss. Through only a few hours delay in starting to haul, the middle nets of the fleet touched the Hearty Knoll in 7 fathoms and were so fouled that we could not save them. The

thirty that were lost held roughly about 5 crans each so the catch would obviously have been a very heavy one had I acted more promptly.

Strangely enough, the best echo-shot during the East Anglian seasons was obtained by shooting on echoes like those in Figure 5 (a). They were seen just before the close of a day in late November 1936 while "Violet and Rose" was manoeuvring for a berth at the Well Bank. My idea was to shoot the nets so that at low-water slack they were in 12 to 15 fathoms on the south side of the Bank, after which the flood stream would take them away southward in deeper water, to return by the next low water — 12 hours later — if we had not hauled before. The tide having ebbed for some time, we were waiting as long as possible to ensure that the gear did not drive on to the Bank proper where, in 7 fathoms, there was a somewhat destructive wreck, when the small peaks began to appear at various depths in 15 fathoms of water. On

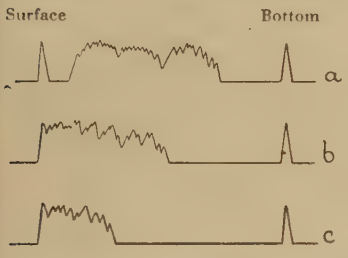

Figure 5.
(a) Echo from herrings swimming in daylight — 26th October 1937, off Yarmouth.
(b) Echo seen at night when herrings were actually seen in the water — Yarmouth.
(c) Echo seen off Peterhead when herrings were 'looping' beside the ship.

seeing these peaks, the nets were put over at once. The catch was 120 crans of large November herring, but as it was intended to shoot there in any case, this can hardly be called an echo-shot in the more strict sense of the summer figures. It is mentioned because of the fine shot of large herring on small peaks, and because there was a gradual swim of herring for almost the whole night. Hauling was not begun until daylight next morning but "looking on" at the first net or two showed a steady increase in their contents every four hours or so. There is no record of the echoes observed during the night.

On another night we were hauling a "shimmer" of about 15 to 20 crans at the Ridge when a good echo began to show at between 5 and 15 fathoms. As quickly as possible the ship was turned and twelve nets shot away again, and while they were being shot, herring could be seen breaking the surface of the water, and the Echometer showed echoes from the transmission peak to 12 or to 15 fathoms. (Fig. 5 (b).) When these nets were hauled again soon after, the first two were practically empty. Then the "shimmer" increased rapidly with each net hauled and the next eight nets each contained about 2 crans of herring (about 2,000). The remainder of the fleet contained only the original 15 to 20 cran "shimmer" and this was evidence that the swim which we had effectively straddled was only a local one. This is one of the few cases in which the echoes are proved to be from herring by actually seing the fish at the time.

The fact remains, however, that the Echometer is ineffective as a practical aid in the autumn fishing and the evidence suggests that this is because of a variation in herring behaviour due to local conditions.

The three most noticeable changes in conditions are: (1) the much less average depth of water at East Anglia: (2) the stronger streams encountered there: and (3) the greater turbidity (or "thickness", as the fishermen call it) of the water. Others perhaps of lesser importance are the longer period of darkness in the autumn, and rather pronounced variation in the contours of the sea-bed, although this latter is a feature of some of the best summer herring grounds. It is quite natural that these changes should produce a difference in herring behaviour and in his "Natural History of the Herring in the Southern North Sea", (1933), H o d g s o n, discussing the fish at Shields and East Anglia, says, "that these two concentrations are composed of herring with different habits, there can be no doubt".

One difference is that the autumn herring frequently swim, and are caught in enormous quantities, during daylight, as the case of 26th October 1937 has shown, but the most important change, from the point of view of the Echometer, is the greatly increased intensity of their swim.

Many years of fishing experience among herring shoals suggest that *the duration of swim is in inverse ratio to its intensity or force* although this has never been scientifically proved, or even tested. Exactly what is meant by "intensity of swim" may best be shown by a brief description of the shot on 21st October 1934, a classic example of Echometer failure.

It was the day before the October full moon, which, when it occurs late in the month, always produces the maximum landings of herring at Yarmouth and Lowestoft. From Yarmouth "Violet and Rose" proceeded 14 miles on an east-south-easterly course, thereby crossing the northern edge of the fan of outgoing Lowestoft boats amongst which our nets were shot. On Sundays, the Scots fleet stays in port so there was plenty of sea room — though the berths taken were not too wide — and by about noon we were all drifting comfortably heading the fresh south-west wind. There were drifters — as far as one could see — in all directions except due north, where only a few were shot.

From the time of shooting we should drift northward with the spring ebb, to stand at low water (at 5·0 p. m. that night, and of great importance in the swim of herring) somewhere very close to the Smith's Knoll lightship which marks the southern end of the bank. (This is the most favoured drive of many East Anglian skippers who call it "ebbing down to the Knoll" or "flooding up from the Knoll" according to the time and position of shooting.)

Drifting is at times a very complicated business. On the one hand, to shoot near the lightship at low-water slack and take the flood up is easy, except when many boats are all trying to do it at once, but on the other hand to leave port with a whole ebb and shoot blind in a position to drive some ten or twelve miles down and be close to the lightship at

low water without fouling her, requires some precision of judgement. As will be seen my judgement was at fault on this occasion.

As herring were known to be plentiful, the Echometer was kept on and carefully watched from 12·30 p. m. until 5·0 p. m. and no echo of any description was seen. The depth peak, giving 28 and later 23 fathoms, was clear and undistorted the whole time during which we covered at least 9 miles of the most prolific herring ground known, and which yielded that night to all boats drifting over it an average catch of over 100 crans.

By 4·30 p. m. it was apparent that "Violet and Rose" and her immediate neighbours were in for trouble. About half a mile west of the lightship is the Watchbuoy by which a check is kept on the lightship's position, and this buoy passed close under our stern before catching and breaking the gear of "Sunnyside Girl", the next boat on our port or south-eastern side.

As "Sunnyside Girl" was hauling rapidly to reach her parted warp we could see that her nets were quite empty of fish. At a later stage of the ebb the stream sets eastward in this area and it was obvious that we also would be parted by the buoy when going up with the flood. So the crew stood ready to haul at my order, which was withheld as long as possible because of the expected swim of herring at slack water.

The boat on our northern side — "Generous" — was now hauling and getting no fish. It was nearly dusk but I saw all these things though my eyes did not leave the sounder more than a few seconds at a time. Finally, as the young flood swung the Knoll lightship's stern to the southward I gave the order and the capstan started heaving in the warp and pulling the ship up to the net. In a few minutes the first net was coming inboard — with a heavy shimmer of herring — every fish alive and undoubtedly newly swum. The "Generous" had got them too. Her nets which a few moments before had been black were now scaling her side, a sheet of silver.

Turning to the temporarily neglected Echometer which was still running, I found no echo was showing, and a quarter of an hour later switched the machine off. As darkness came the boats all around began to haul literally thousands of tons of herring. So intense and sudden was this swim that the nets were full in a matter of minutes — perhaps evens seconds. This is certainly not an isolated case. Swims of such short duration are frequently experienced in East Anglian waters and the nets must be in the water beforehand to be of any use.

It is important therefore to discover, if possible, the reason why the machine cannot be used in a negative sense, i. e., "absence of echoes does not prove absence of herring" as previously stated. This rule applies also in summer when the sounder is useful in a positive way.

The herring will give echoes during the swim in autumn and also in summer when swimming in any appreciable vertical thickness either in mid-water or at the bottom. What, then, is the explanation of complete absence of echoes at other times? This involves some consideration of

herring behaviour, a field of fishery research practically neglected so far, except for some preliminary observations by Michael Graham of Lowestoft in 1931 on some trips he made in East Anglian drifters that autumn.

Certainly the swim of herring so frequently mentioned here is of vital importance to drifters, for without it, their long walls of netting hanging motionless in the water are quite ineffective. Most fishermen believe it to be a concerted movement of the fish starting upwards from the bottom to which they return when the swim is over, but Graham does not agree that the herring go to the bottom at all. Explaining the swim as an emotional state in which the fish are unable to avoid the nets he suggests that at all other times they are swimming casually about, between and around the nets without becoming enmeshed.

If this conception were correct the Echometer would probably be almost infallible in locating them, but most evidence supports the fishermen's theory — the enormous catches of herring trawled from the bottom for instance, which are known to have a diurnal rhythm consistent with shoals rising at night. And the even more pointed, but lesser known, cases in September on the Dogger Bank, where English drifters have hauled blank nets from the surface waters beside Frenchmen, whose sunk nets have practically swept the bottom, getting heavy catches.

A somewhat rare phenomenon that occurs in summer, usually on a calm day, is that vast numbers of herring may be seen rippling the surface like a wind. Fishermen call this "schooling" and associate it with a general move by the herring because frequently catches that night are very small. In one such case I noticed the fish were striking swiftly upwards at an angle of about 45° before breaking surface near the ship. "Schooling" should not be confused with "looping" when individual herring only keep showing. This often occurs during the swim at the close or at night and almost invariably means a good catch.

It seems to be an acceptable fact that herring spend most of the daylight period at, or very near, the bottom. The swim therefore is possibly a habit evolved by a long struggle between one desire to avoid the light and another to rise from the bottom for food amongst the plankton of the higher waters; or possibly by the rhythm of daylight and darkness alone. Once formed, such a habit would evince itself in any one of the many conditions or circumstances usually associated with the swim and would also explain the swim in non-feeding shoals.

If this is the case the echoes seen at Shields, which are generally from shoals about 100 feet in length, would seem to indicate comparatively small bodies of herring beginning to rise from the bottom some time before the general swim at night, but at East Anglia apparently this does not often happen, and it is this difference, only a slight variation in herring behaviour, that tips the balance against the Echometer. Obviously it is of little use to steam about searching for herring which can only be seen during the swim when it is too late to shoot drift-nets and catch them.

Hodgson says the herring at East Anglia are migrating towards their spawning ground, so it is likely that they are closely concerned with the bottom. But the question arises, Is it possible for such vast numbers of them to be at the bottom in such way as to give no echo? The following calculation is a shot in the dark but seems to suggest that they can.

Taking the average catch on the night of 21st October 1934 as 100 cran we can say that 10 fleets of nets in an area 2 miles square caught 1,000 crans, which is approximately 1 million fish. What proportion this catch was of the actual stock of herring in that area is of course unknown.

If we assume the proportion of catch to stock to be 1 : 400 that would give 100 million herring to the square mile, or 27 million square feet. Thus the water only one foot from the sea-bed would supply more than a cubic foot for every four herring.

This estimate of the stock may be open to criticism. If it is low, quite probably twice the number of herring could be sustained in the foot or so of water adjacent to the bottom for the duration of a tide, and maybe longer. And they would not show an echo however dense the lateral congestion was, for the width of a fathom is only one-tenth of an inch on the scale of the sounder.

This hypothesis is based on an old belief, now hardened by the Echometer's evidence, that phototropic force is the most important influence in herring behaviour. (If this is the case the comparatively shallow waters fished at East Anglia would be a reasonable explanation of the difference in behaviour mentioned.) It is also probable that the action of this force in holding the fish to the bottom makes contour of ground a considerable factor in their migration and degree of concentration.

I have often noted the coincidence of good herring catches with those places where the contour lines on the chart come closer together, and a study of fishery reports (if reliable particulars were available) from this angle might lead to interesting results.

The picture suggested is of a groundsheet of waving tails, with each herring kept nosing the ground by its desire to avoid the light, and its natural swimming tendency satisfied by stemming the stream until the changed conditions at slack water become temporarily more powerful than the influence of light and induce the sudden upward swim. Much of this argument is of necessity pure supposition. Whether or not it is the correct explanation, only time and investigation will prove.

Conclusion.

It is hoped that the two main points of this account may form the base for a newer and improved method of operations in future. If it were possible to adopt the Asdic principle to fish-echo work its swinging beam would mean a much greater area of search, which, in summer, would almost certainly bring better results. But this would hardly

overcome the East Anglian difficulty. Here, it seems, some altogether new approach is required but in exactly what form is hard to say.

The notes kept in "Violet and Rose" might have been more consistently taken, especially of echoes seen after shooting to provide data on duration of swim, but this may be possible in further work. For the scientist, there is a source of much material on herring behaviour in the fishermen's knowledge if it could be properly tapped.

In Professor H a r d y' s great experiment to ascertain the correlation of herring catches with the presence of certain plankton forms some 1,200 reports came from skippers who not only wrote the required details in a book of forms, but also carefully placed their linen-wrapped sample disks in preservative after towing them.

I had the pleasure of helping in this work and know skippers who were most conscientious in doing their part. As H a r d y says, it must be made easy for the skippers to supply the information. Handy notebooks ruled off under suitable headings like times of shooting and hauling, time and direction of swim, etc., would, if given to selected men, probably yield some useful data in a year or two.

As for the Echometer, already a recognized part of the trawler's equipment, it has been regarded as an expensive luxury in drifters during lean years. But some skippers I know would have preferred it to the radio telephones being fitted by their owners.

Finally, while this first attempt in commercial fish-echo work is something of a failure, I hope it may prove to be a small link in the chain of evidence required for an adequate working knowledge of that great fish farm, the North Sea.

The Distribution of the Sprat in the Middle Baltic during the Summer of 1939.

By

Zygmunt Mulicki.

THE present article deals with investigations into the behaviour of the sprat in the central part of the Baltic during the summer of 1939. It continues and supplements the paper by B. Dixon and Z. Mulicki, "Sprat investigations in the Middle Baltic during the summer of 1938", prepared for the press but not yet published. Its purpose is to comment on the location of the sprat during the summer period, their migration and vertical distribution during this period, and on analyses of the stock as regards sex, maturity and body length.

The data were collected on two voyages of the fishery cutter "Gustaw" during the periods 20/6—8/7 and 13/7—26/8 1939. Sprats were caught from this cutter with drift-nets of 11·5—12 mm. meshes. Separate nets 20 m. long and 5 m. deep, were connected as a fleet, but set at different depths. Some were fitted with cork floats along the

Figure 1. Arrangement of drift-nets for fishing at different depths.

upper edge of the net and fished just below the surface; others were set to fish at various depths by means of vertical ropes of suitable length, attached to glass floats on the surface. In order to keep the nets vertical and to ensure their accurate spreading, their lower edges were weighted with stones, suspended on thin lines. By using a fleet of drift-nets arranged in this way (Fig. 1), it was possible to fish at various depths, namely 0—5, 5—10, 10—15, 15—20, 20—25 m.

The number of drift-nets set varied on the particular stations from 12 to 30 the number of nets was highest (3—15 drift-nets) at the two uppermost levels; the deeper ones were less numerous (2—9 drift-nets). The nets were set for the whole night and hauled in the morning after 6—14 hours. They were left to drift either quite freely, with the ends of the fleet marked by floats carrying a lantern, or with one end

attached to the fore part of the cutter, which drifted with the fleet. In general 436 drift-nets were set on 19 nights, and 7109 sprats and 4575 small herrings were caught.

Table 1.
Locality of Catches and Number of Sprats caught.

Station No.	Date 1939	Position Lat. N.	Long. E.	Depth m.	Number of sprats	Number of drift-nets
1	21—22. 6	54°57′	16°38′	14	8	30
2	24—25. „	55°03′	15°34′	70	466	30
3	28—29. „	55°35′	16°07′	68	140	30
4	29—30. „	56°16′	17°10′	27—39	226	26
5	30. 6—1. 7	56°45′	18°33′	19	19	24
6	5— 6. 7	57°03′	17°40′	100	1974	24
7	6— 7. „	56°02′	18°41′	96	692	23
8	7— 8. „	55°19′	18°46′	85	74	23
9	13—14. „	54°57′	19°13′	96	7	24
10	15—16. „	55°01′	18°00′	27	14	23
11	23—24. „	55°45′	20°04′	85	2	25
12	24—25. „	56°23′	20°51′	24	190	25
13	3— 4. 8	56°34′	20°25′	69	3	25
14	8— 9. „	57°03′	17°32′	97	480	25
15	10—11. „	56°12′	16°10′	35	2806	20
16	20—21. „	55°48′	15°32′	42	6	17
17	23—24. „	55°19′	15°31′	90	—	15
18	24—25. „	55°28′	17°24′	17	—	15
19	25—26. „	54°53′	18°19′	20	2	12
				Totals	7109	436

Horizontal Distribution of the Sprat.

The catches were made at 19 stations, listed in Table 1, and shown on the map Fig. 2. The region of the covered Baltic is limited on the north by the parallel of 57°N. lat. On the west it reached as far as Bornholm, and on the south and east the Polish and Latvian coasts. According to distance off shore the grounds may be divided into coastal and open sea stations. Stations 2—3, 7—9, 11, 17—18 belonged to the latter group; the remainder not being more than 25 sea miles off shore, may be classed as coastal.

The catches showed that in the period from June to August, the sprat was to be found over all the area investigated in larger or smaller quantities. The larger quantities occurred in coastal regions, which accords with the 1938 results; at 8 open sea stations 1,381 sprats were caught, while at 11 coastal stations the number was 5,728. For the open sea, the average is 7.5 sprats per net, while for the coastal stations it is about 23, three times as many. In May the larger quantities of fish were found

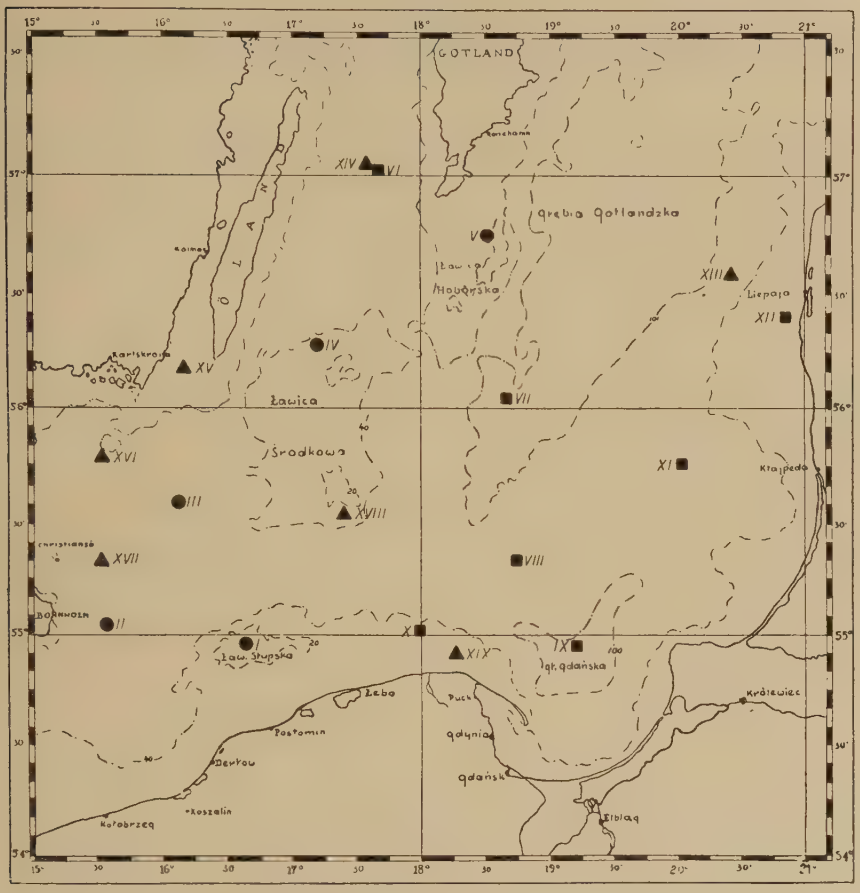

Figure 2. Location of stations at which sprats were fished.
● — in June. ■ — in July. ▲ — in August.

in coastal regions; in June the sprat moves out to the sea, and in the two following months the fish assemble again closer to the coast. The monthly quantities of sprats per drift-net from May to August are as follows:

	Coastal Stations	Open Sea Stations
May[1])	13·3	—
June	3·1	10·1
July	30·2	8·2
August	33·3	0
average	22·8	7·5

[1]) The data for May relate to the 1938 investigations.

Table 2.
Numbers of Sprats per Drift-Net in the Different Water Layers (0—25 m.)

Stations	Water Temperature °C					Number of Sprats per Drift-Net Depth m.					
No.	0-5 m.	5-10	10-15	15-20	20-25	0-5	5-10	10-15	15-20	20-25	0-25
1	14·3	13·2	—	—	—	0·3	0·2	—	—	—	*0·3*
2	14·3	14·2	13·2	—	—	19·3	16·5	10·8	—	—	*16·6*
3	—	—	—	—	—	4·0	2·4	5·2	7·8	—	*4·7*
4	—	—	—	—	—	13·9	16·0	2·3	0·2	—	*8·7*
5	—	—	—	—	—	1·1	1·3	0·1	—	—	*0·8*
6	—	—	—	—	—	21·0	56·0	169·8	—	—	*82·2*
7	—	—	—	—	—	28·5	18·8	42·1	31·0	—	*30·1*
8	—	—	—	—	—	0·2	2·7	8·5	1·2	—	*3·2*
9	16·1	15·9	15·5	14·0	—	0·2	0·2	0·3	0·5	—	*0·3*
10	16·1	15·4	15·3	15·2	—	0·7	0·5	1·2	—	—	*0·6*
11	18·6	18·0	17·0	16·0	12·8	—	—	0·2	0·2	—	*0·1*
12	17·9	17·6	16·9	16·3	16·2	—	7·2	14·4	7·6	8·8	*7·6*
13	19·0	19·0	18·3	17·8	14·0	0·2	0·2	0·2	—	—	*0·1*
14	18·7	18·6	17·4	10·8	7·2	32·8	24·6	28·2	10·2	0·2	*19·2*
15	—	—	—	—	—	1·6	166·0	242·0	151·6	—	*140·3*
16	18·6	18·4	17·1	12·3	13·1	0·3	0·2	0·5	0·2	0·5	*0·4*
17	—	—	—	—	—	—	—	—	—	—	—
18	—	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	0·3	0·2	—	—	—	*0·2*
average						*7·3*	*15·5*	*30·0*	*16·6*	*1·8*	*16·3*

At the open sea stations, the largest concentrations occurred in June; during July they diminished, and in August no sprats at all were present. In the neighbourhood of Slupsk, Middle, and Hoborg Banks, sprat were found in small numbers, which is an uncommon occurrence, since in July the previous year, the Hoborg Bank was one of the most productive localities. The northern parts of the area investigated (north of 56°N. lat.) yield much greater numbers of sprat than the southern, in the proportion 33 : 3. Also the western part of the area (west of meridian 18°E. long.) shows larger concentrations than the eastern, in the proportion 26 : 5. Accordingly the best catches were made in the north-western parts of the region, near the islands of Gotland and Öland. It must be emphasized that the shoals usually consisted of sprat and herring mixed. The small mesh of the nets used allowed only small herring to be caught, which amounted to 39 % of all catches. They were caught everywhere except on the banks.

Vertical Distribution.

The arrangement of the nets as described enables an insight to be obtained into the distribution of the sprats from the surface down. The relevant data are listed in Tables 2 and 3, and illustrated in Figures 3

Table 3.
Sex and Maturity of the Sprat Stocks at Different Depths.

Stations	Date	Depth, m.	Number of fish	% ♀♀ running	% ♀♀ non-running	% ♀♀ total	% ♂♂ running	% ♂♂ non-running	% ♂♂ total	No. of fish per drift-net
1—5	21.-30. 6. 1939	0— 5	336	5·7	47·6	53·3	14·3	32·4	46·7	7·0
		5—10	308	8·8	32·1	40·9	28·2	30·9	59·1	6·6
		10—15	167	5·4	14·4	19·8	44·3	35·9	80·2	4·9
		15—20	48	4·2	2·0	6·2	79·2	14·6	93·8	4·4
		0—20	*859*	6·6	33·1	*39·7*	28·8	31·5	*60·3*	6·1
6—12	5.—25. 7. 1939	0— 5	345	13·0	43·8	56·8	23·2	20·0	43·2	8·2
		5—10	617	6·5	23·7	30·2	32·4	37·4	69·8	14·7
		10—15	1744	1·4	5·4	6·8	45·2	48·0	93·2	41·5
		15—20	203	0·5	13·3	13·8	58·6	27·6	86·2	6·5
		20—25	44	—	59·1	59·1	6·8	34·1	40·9	4·4
		0—25	*2953*	3·8	15·0	*18·8*	40·3	40·9	*81·2*	17·7
13—19	3.—26. 8. 1939	0— 5	167	—	89·2	89·2	—	10·8	10·8	6·5
		5—10	126	—	80·9	80·9	—	19·1	19·1	29·9
		10—15	144	—	75·7	75·7	—	24·3	24·3	41·0
		15—20	52	—	75·0	75·0	—	25·0	25·0	36·8
		20—25	2	—	+	+	—	+	+	0·1
		0—25	*491*	—	81·5	*81·5*	—	18·5	*18·5*	17·8
Total		0— 5	848	7·6	54·2	61·8	15·1	23·1	38·2	7·3
		5—10	1051	6·4	33·0	39·4	27·3	33·3	60·6	15·5
		10—15	2055	1·7	11·0	12·7	41·9	45·4	87·3	30·0
		15—20	303	1·0	22·1	23·1	51·8	25·1	76·9	16·6
		20—25	46	—	58·7	58·7	6·5	34·8	41·3	1·8
		0—25	*4303*	3·9	26·2	*30·1*	33·4	36·5	*69·9*	16·3

and 4. They indicate that in summer the sprat occurs in largest numbers (30 fish per net) in the water layer 10—15 m. The adjacent layers both above and below, yield numbers smaller by half, the surface layer still smaller numbers,while in 20—25 m. layer sprats are rarely present. The conditions described relate to the summer season as a whole, but for particular months they change, and we may notice the gradual descent of the sprat into the deeper water layers, the upper layers become warmer (Fig. 4). As has already been shown (L. F a g e, 1920, K. D e m e l, 1938), the movements of the sprat depend in a high degree upon the temperature and the currents.

The vertical distribution of sprat, in relation to sex and maturity, is discussed in the following section.

Spawning.

In 1938 the highest intensity of the spawning of the central Baltic sprat occurred at the end of May, at an average water temperature of

8·1°C. Spawning ceased between 10. and 27. July, when the water temperature reached 10·6—11·2°C. In the 1939 investigations which were begun — on account of technical difficulties — one month later, neither the beginning nor the culmination of the spawning were observed, but only its final phase, which was rather extended in time. It was finally over between 25. July and 3. August, about the same time as in 1938. The last running females, which condition may be taken as the criterion of spawning, were caught on 25. July off the coast of Latvia (St. 12). The next catches at a position not far distant (St. 13), on the night of 3.—4. August and later ones, gave neither running females nor running males.

The running females were caught at Stations 2—8 and 12, the running males on Stations 1—12. It can be seen from the location of these stations on the chart that spawning takes place both in the coastal regions, and at points some distance from the coast. One cannot therefore define any particular spawning place.

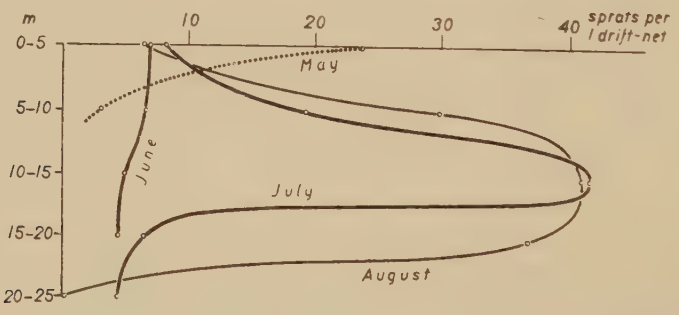

Fig. 3. Density of sprats in the different water layers during summer.

The upper limit of the temperature at which spawning took place was 16·2—17·9°C. The summer of 1939 was very hot and the temperature of the upper 15 m. of water in the middle of July was about 4° higher in comparison with the temperature at the same time of the previous year, although the water temperature in mid-June was almost the same in the two years. It is therefore evident that spawning can take place in temperatures higher than 11·2°C (L. F a g e, 1920, B. D i x o n and Z. M u l i c k i) and that an unusually high water temperature during the spawning period has no influence on the duration of the period.

Comparatively few of these spawning sprats were caught, the number being only 1605 fish, that is 32·6 % of the total catch. For June and July together they amounted to 42·1 % of the catch, while in August there were none. Running males were the more numerous, comprising 37·4 %; the percentage of females was only 4·7 %. These conditions are shown for particular months and for various depths in

Table 3 and Figure 4. It may be seen that in general for 30 females there are 70 males. This relation is not strict and changes from month to month, and corresponding changes occur in different water layers. During the spawning period, that is, in June and more especially in July, the males predominate in the catches; after spawning is over, in August, this relation is reversed, the females becoming the more numerous. Since in August only the coastal regions yielded catches of considerable size, and no sprats at all were taken at the open sea stations, it

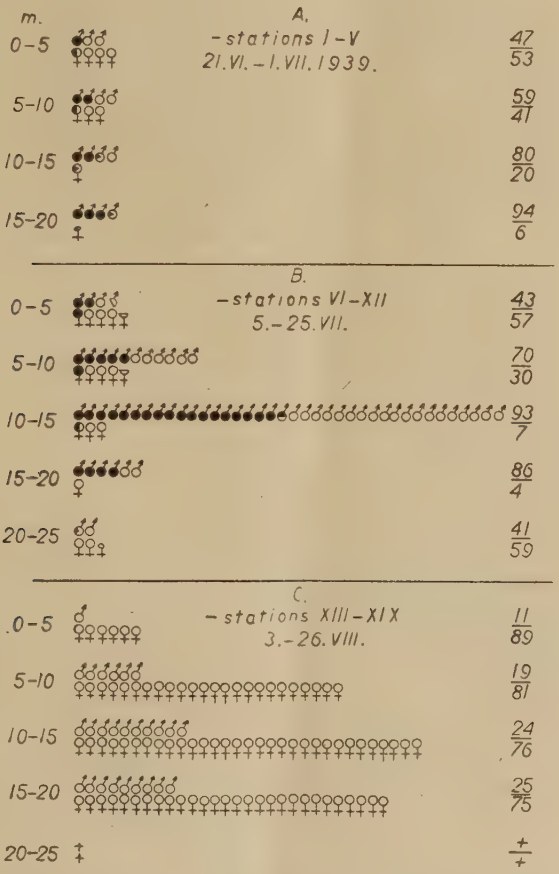

Figure 4.
Distribution of sprats of both sexes in different depths. A and B — during spawning, C — after spawning, ♂ ♂ — 1 running and 1 non-running male, ♀ ♀ — 1 running and 1 non-running female per drift-net, + — presence of sprats in insignificant numbers.

may be supposed that the large numbers of females which appeared on the coast moved in from the open sea after spawning. According to our data the percentage of mature males participating in the spawning is much greater than the percentage of recorded running females. As was demonstrated by H e i d r i c h (1925), the females extrude their eggs in 8 or 9 groups at intervals of 8—10 days. During the spawning, the females keep mostly to the upper layers, while the males, especially the

running ones, remain rather deeper. So, for every 5 m. interval from the surface, we have at the end of June 2·5, 3·2, 8·2, and 19·0 running males (average 4·3) for every running female. The corresponding figures for July are 1·8, 5·0, 31·5, and 119·0 (average 10·7). This, of course, is the distribution during night, since the drift-nets were always set in the evening and hauled in the morning. Whether the distribution changes during the day is not known.

The Length and Age of the Sprat Stock in Summer.

The body length of the sprats caught by our drift-nets in 1939 varied from 9 to 15 cm., with an average value of 12·4 cm. This value is higher than that of former years. Since the season of 1931/32 the average lengths have increased as a result of the increase in the growth-rate of the sprat, caused probably by the greater intensity of fishing (B. D i x o n, 1938). For particular stations the average lengths are as follows:

Stations	♀	♂	♀ + ♂
1—2	12·2 cm.	12·0 cm.	12·1 cm.
3	12·3	12·3	12·3
4—5	12·6	12·4	12·5
6	12·5	12·0	12·1
7	12·9	12·6	12·7
8—10	12·7	12·4	12·5
11—13	13·0	12·6	12·8
14	13·3	12·7	13·2
15	?	?	12·8
Average	12·7 cm.	12·2 cm.	12·4 cm.

The table shows that the average length is greater in the females than in the males and changes not only from place to place but also in time. An example of the change of length in the stock in time is given by the catches at 2 stations near Gotland (St. 6 and 14), situated very close together. At St. 6, on 6. July the average length of the sprats caught amounted to 12.1 cm., while at St. 14 a month later it was 13·2 cm. This considerable difference in average length may be ascribed partly to the great predominance of females at St. 14, and partly to the larger size of the fish generally, both females and males.

The average length of spawning sprats is slightly greater than that of non-spawning fish. For comparison we give the mean length of running and non-running fish of both sexes for June and July together (St. 1—12):

		Average Length	
females	168 running	12·68 cm.	(10 —14·5 cm.)
	729 non-running	12·52	(9·5—15·0)
males	1435 running	12·28	(9·5—14·0)
	1478 non-running	12·13	(9·0—14·0)

It appears (St. 13—15) that during August, after spawning, larger fish, both males and females, enter the shoals, their average lengths reaching 12·7 and 13·3 cm., or 13·1 cm. for males and females together.

The age composition of the sprats in 1939 was not determined, since the collection of otholiths was lost during the war. We therefore give the composition of the stock in summer 1938, as percentages of fish in the different age-groups, together with mean lengths (B. Dixon and Z. Mulicki): —

Age-Group	II	III	IV	V	VI
Number per cent.	11·3	34·3	43·4	10·6	0·4 %
Mean length	10·3	11·4	12·7	13·4	— cm.

Discussion.

These investigations, as well as those of the previous year, into the biology of the sprat were undertaken with the object of finding, if possible, an explanation of the falling off in the catches which began suddenly after the good season of 1935/36, and which has been so disastrous for the Polish fishery.

They confirm the fact that the supplies of sprat in the central Baltic are inconsiderable, as had already been suggested by W. Mankowski's study of the eggs and larvae taken in contemporary Hensen net hauls. This state of affairs was explained as resulting from overfishing (B. Dixon, 1938) and unfavourable climatic conditions (K. Demel, 1937, 1938).

The data on the horizontal distribution of the sprat in the summer of 1939 show that only the southern and especially the south-eastern parts of the Baltic were short of sprats. This accords with the catch statistics, from which it appears that the disastrously poor sprat fishery was confined to the southern part of the Baltic only, where normally the largest catches are made. The Finnish, Latvian, and Swedish catches remained at about the same level (Table 4). On the other hand, when the sprats were disappearing from the Gulf of Gdansk, the catches in the Belt, Kattegat, and Skagerak increased.

Table 4.
The Catch of Sprats in the Baltic and Transition Area from 1932—1938, in Tons[1]).

	1932	1933	1934	1935	1936	1937	1938
Finland	494	607	631	627	705	557	401
Latvia	734	694	640	980	998	757	620
Sweden	60	60	127	128	144	93	108
Poland	5433	5547	7448	10408	15081	2891	50
Germany	2641	3363	4544	5818	6450	992	259
Transition Area	2991	1580	2326	3489	4359	5349	9822

[1]) Data from Bulletin Statistique des Pêches Maritimes, 1932—38.

These facts suggest that the sprats fished in the Gulf of Gdansk are peculiar to that region. This would accord with the findings of E h r e n b a u m (1919) and D i x o n (1937), who separated the eastern from the western Baltic sprat, on the basis of differences in growth.

Our comparison of the sprats from the northern and southern parts of the Baltic, on the basis of mean length, led to no definite conclusions. No race investigations, based on the number of vertebrae, were made, since the collection of material was lost during the war.

Observations made during the summers of 1938 and 1939 complete our knowledge of the life history of the sprat through the year. As far as the sprat of the Gulf of Gdansk is concerned it was known that it made its first appearance on the coast in October. It moves along the coast towards the southern shores of the Gulf of Gdansk, and tends to seek the deeper water layers as the surface temperature becomes gradually lower. When winter temperature conditions set in, the fish gather in compact shoals in the bottom layers and remain there all the winter. In spring, when the temperature of the water column is homogeneous, the shoals rise to the surface, and in April or the beginning of May, they migrate offshore (K. D e m e l, 1938).

Our investigations show that during the period May to the end of July, that is the spawning period, the sprat is distributed over all the central Baltic. After the spawning period, that is, in the beginning of August, the fish undertake their return migration, and leave the central parts of the Baltic to gather in the coastal regions. There they form the shoals which set out for the southern part of the Gulf of Gdansk in autumn.

Summary.

This paper presents the results of investigations carried out in summer, that is, in the spawning period and afterwards (20/6—26/8 1939), and contributes to our knowledge of the annual cycle in the life of the central Baltic sprat. The following conclusions were reached: —

1. The sprat is distributed all over the central Baltic in the summer period, the density of fish being 3 times smaller in off-shore regions than in coastal waters.

2. The density of the sprats in the northern part of the central Baltic (north of 56°N.) exceeded their density in the southern part in the proportion 33 : 3. That in the western part (west of 18°E.) exceeded that in the eastern, in the proportion 26 : 5. This finding, which is conformed by the statistical data on commercial catches, indicates that the disappearing of the sprat is confined to the south-eastern part of the Baltic only, and suggests that the Gulf of Gdansk shoals are peculiar to that district.

3. The number of sprats per drift-net for each 5 m. interval from the surface to 25 m. depth amounted to 7·3, 15·5, 30·0, 16·6, and 1·8 (average 16·3).

4. As the surface water becomes warmer the fish descend into the deeper, colder layers.

5. Spawning takes place in both open-sea and coastal regions.

6. In 1939 spawning took place at a water temperature of 17·9°C., that is, higher than in 1938 (8·1—11·2°C.), and was over between 25/7 and 3/8, as in 1938.

7. During the spawning period, the males tend to keep to the deeper layers, the females to the shallower. While spawning is in progress, male fish are the more numerous; after spawning females predominate.

8. The length of the sprats caught varied from 9 to 15 cm., with an average for females of 12·7 cm., for males, 12·2 cm., for both sexes together 12·4 cm. This value is greater than in previous years since 1931. The minimal length for mature females was 10 cm., for males, 9·5 cm.

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Spawning and Growth of Young Mackerel on the Norwegian Skagerak Coast.

By

Alf Dannevig.

THE mackerel has not been the object of special investigations in our waters. Occasionally, however, we have touched upon it, and as our observations may elucidate the problem of the growth of the young, a survey of the data may be of interest.

Some years our pelagic fishing for the eggs and young of our winter and spring spawners has been continued till late in June. The earliest date at which we have observed mackerel eggs is 14. to 16. May (1917 and 1934). They occurred only sporadically. Great quantities of mackerel eggs were caught outside Jomfruland on 31. May and 1. June 1937, which was the earliest date at which full spawning took place. During the month of June the eggs are very common, but as to the latest occurrence we can say nothing, as we have made no regular hauls in July in these waters.

It is interesting to note that in some years we find the earliest eggs present simultaneously in the fjords, in the skærgård, as well as outside the coast. During the chief spawning we find very few eggs in the fjords, but enormous quantities outside the coast. It is likely that the most intense spawning takes place here, where the surface layer has its greatest thickness.

The earliest eggs are found in water with a temperature of 8°C. The temperature observed at earliest full spring spawning is 12°C.

The earliest date at which mackerel larvae were observed to occur is 29. to 31. May 1937. A few individuals were collected in the hauls near Kragerø, both in the fjords and in the Skagerak. Great numbers are found in the last half of June, always outside the coast. The size of the young is from 3 to 15 mm. In July no hauls have been made in these waters. In the Oslofjord, however, we caught 30 larvae and young, 4 to 19 mm., in the period 4. to 11. July 1938.

The overall length of Young Mackerel on the Norwegian Skagerak Coast.

Length	1925			1937						1938			
cm.	12.8.	17.8.	17.8.[1])	13.8	25 8.	1.9.	4.9.	15.9.	27.9.	12.8.	13.9.	15.9.	19.9.
5	—	—	—	—	—	—	—	—	—	2	—	—	—
6	—	—	—	—	—	—	—	—	—	6	—	—	—
7	—	—	—	—	—	—	—	—	—	3	—	—	—
8	1	—	—	—	—	—	—	—	—	—	—	—	—
9	9	1	—	—	—	—	—	—	—	—	—	—	—
10	5	9	—	—	—	—	—	—	—	—	—	—	—
11	—	7	—	—	—	—	—	—	—	—	—	—	—
12	7	3	1	2	—	—	—	—	—	—	—	—	1
13	19	5	2	3	—	—	1	—	—	—	—	2	—
14	17	4	1	10	—	—	4	—	—	—	—	—	—
15	8	1	1	74	1	—	2	—	1	—	—	5	—
16	—	—	—	11	25	6	8	1	1	—	—	2	—
17	—	—	—	—	60	22	15	—	4	—	4	9	5
18	—	—	—	—	13	46	52	1	31	—	4	27	8
19	—	—	—	—	1	22	17	2	155	—	2	25	2
20	—	—	—	—	—	4	1	9	141	—	1	23	3
21	—	—	—	—	—	—	—	3	24	—	—	13	—
22	—	—	—	—	—	—	—	—	3	—	—	2	—

[1]) Taken from the stomachs of full-grown mackerel.

Later in summer we have occasionally caught a few young mackerel in a small seine in the littoral region, and a few were taken from the stomachs of full-grown mackerel, pollack, and sea-birds.

In the table the total length is given for the most representative samples. The smallest were taken, together with young sprat, on 12. August 1938; these range from 5 to 7 cm. A sample taken on 12. August 1925 consists of considerably larger fish, from 8 to 15 cm. Late in August the size of the young collected varies around 17 to 19 cm., the largest individuals being 22 cm. Do these fish belong to the 0-group?

The estimation of the age of the mackerel by annual zones is somewhat uncertain. No winter zones are, however, to be found in the vertebrae or in the scales of the individuals mentioned above, which in my opinion belong to the 0-group: in the autumn we never find smaller individuals.

This opinion as to the growth of the mackerel has been verified in recent years by observations in our saltwater ponds. The eggs or larvae are brought into the ponds with the pump water. Some observations from 1939 and 1945 will be of interest.

In the rearing pond some young mackerel were observed on 3. August 1939, with lengths approximately 6 to 8 cm. On 5. August two mackerel had escaped from the pond into the apparatus for lobster rearing; these measured 8 cm. The next day one more of the same length was found in the same place. This last one was placed in an aquarium where it thrived quite well. It fed eagerly on some crustaceans (mysis etc.) and

grew quickly, but when the crustaceans had come to an end, and we began to feed it with "dead matter", the growth stopped, its condition deteriorated and it died on 1. September the same year; the length was then 10·5 cm. In the pond one mackerel was observed on 13. September, 12 to 13 cm. long and in very poor condition.

In the oyster pond two mackerel about 12 cm. long were seen on 1. September, and on the 15th, 20 mackerel of about 15 cm. in length. As the pond had been emptied in the spring, the mackerel must belong to the 0-group.

On 23. June 1945 I observed a small fish, apparently mackerel, about 4 to 5 cm. long in the oyster pond. Three weeks later, on 13. July, I identified 8 mackerel about 6 cm. in length. The growth of the mackerel is thus extremely rapid during its first summer.

During winter the mackerel caught in our waters are very thin, and a high growth-rate is then not to be expected.

Mackerel (*Scomber scombrus* L.) on the South Coast of Finland in the Autumn of 1936.

By

Ilmo Hela.

MACKEREL is a very rare visitor to the Finnish waters. It may be caught by chance in some years, and even then the catch usually consists of but one or two individuals. According to reports collected by T. H. Järvi, 90 mackerel in all were, however, caught in the autumn of 1936. Of these fish, 30 were taken near Utö (59°47′N., 21°22′E.), 8.—9. October, and 40 in the waters of Hanko (59°49′N., 22°58′E.) and Porkkala (59°56′N., 24°25′E.), 13.—15. October. Almost all of them were from spawn of spring 1935.

All the mackerel caught on the coasts of Finland are evidently individuals that have drifted from the Kattegat. It is consequently possible to use this exceptional case to draw certain conclusions concerning the deep currents in the Baltic.

The surface currents in the Danish waters are mostly directed outwards from the Baltic Sea. The westerly winds, however, occasionally cause, even in the surface layer, a current directed inwards. According to the air pressure observations made in Hamburg and Oslo, the corresponding pressure gradient reaches its maximum in October. More detailed investigations show, that October is a particularly favourable month for the winds and currents in the Danish waters to drive the surface water of the Kattegat into the Baltic together with the organisms living in it.

We have to look for the reason of the abundant mackerel catch of autumn 1936 in the currents of the Danish waters between spring 1935 and autumn 1936. As mentioned above, the primary reason probably lies in the current conditions of October 1935. As a result of the cyclones over northern Europe from 9.—21. October, there were almost continuous westerly winds in the area of the Danish waters, and also

a strong ingoing surface current flowed without any intermission. Both in the Sound and in the Great Belt the maximum speed of the surface current was nearly 200 cm./sec. At the end of the period the salinity at all hydrographical stations was exceptionally high. For instance, at the Danish lightvessel "Drogden" (55°32·6′N., 12°43·1′E.) the salinity was 24·2 ‰, the average value for this season being only 10·5 ‰. In the salinity records of "Drogden" higher values do not seem to appear during the period April to November. (It is necessary to emphasize that the mackerel leaves the waters of the Kattegat and Skagerak in November, lives during the winter months in the deep hollows of the North Sea, and comes back in April or May.) It is worth mentioning that in 11 days, from 9. to 20. October the mean water-level of the Baltic rose by 34 cm. from MW+11 cm. to MW+45 cm. Thus the quantity of water in the whole Baltic increased during these 11 days by about 0·5 per cent.

With the approach of the winter the young mackerel in the Baltic tend to seek deep water and are then transported by the slowly moving deep current. In a previous paper I have attempted to show that the deep current moves from the Danish waters to the south coast of Finland in from 12 to 19 months, corresponding to an average speed of about 3 cm./sec. According to this result, it seems probable that the deep current drifted the mackerel to the Finnish waters in about twelve months.

The mackerel of Utö were caught on 8.—9. October. This circumstance can be explained in the following way. During 4.—6. October a very strong cyclone gave rise to northerly winds in the Gulf of Bothnia and north-easterly winds in the Gulf of Finland. On account of this storm the boundary layer was raised in the eastern parts of the Gulf of Bothnia and also in the waters of Utö. The mackerel were transported to the vicinity of Utö by the currents associated with this phenomenon. It seems probable that because of a corresponding current in the area of the Gulf of Finland, the mackerel drifted to its southern parts.

During this phase the boundary layer in the southern parts of the Gulf of Finland was raised almost to the surface. A period of strong southerly and south-easterly winds, beginning on 12. October, no doubt gave rise to a deep current moving at a high speed from the southern parts of the Gulf of Finland to Finnish waters. This current probably explains the mackerel catch in the area of Hanko and Porkkala between 13. and 15. October.

Baltic Salmon and Trout.

Guide to Determination.

By

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THE difficulty in distinguishing salmon from trout[1]) is primarily due to the fact that the individual fish is so very different during its successive periods of life and that the visible differences between the two species, properly speaking, are not absolute, but consist only in "more or less", because some characteristics (colour, length of fins, etc.) are more developed in one and less in the other species.

If two fish of the same size are compared, most people can easily tell which is the salmon and which is the trout, and in most cases the expert is not in doubt. But to the person who has perhaps so far seen silvery salmon only it is by no means easy to recognize the species if he sees a male salmon in its richly coloured spawning dress or perhaps a small, young salmon that is like a brook-trout. In other words, we are not able to describe the salmon in such a way that all its different aspects are covered, and this is also true of the trout. In order to make an accurate determination, it is necessary — until one is fully experienced, which may take a long time — to confine oneself to a

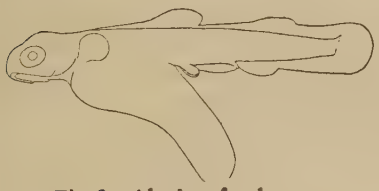


Fig. 1. Alevin of salmon.
From Schindler.

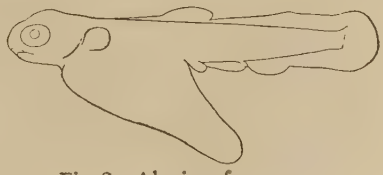


Fig. 2. Alevin of sea-trout.
From Schindler.

[1]) Attempts to distinguish between salmon and sea-trout in the various stages of their life history present considerable difficulties in some areas. In Great Britain, Iceland, Ireland, and Norway a fairly simple solution to the problem is at hand but in the Transition and Baltic areas such is not the case. In these regions even experienced fishermen may have considerable difficulty in distinguishing between the two species in fish approximately the same size. This paper is, therefore, intended to deal solely with the characters of the two species as found in the Transition and Baltic areas, sufficient authoritative work having been published on this subject for other areas. *Editor.*

Fig. 3. Alevin of salmon 24 mm. 2 × magn. (Top). — Alevin of trout 23 mm. 2 × magn. (Bottom). From Johansen & Løfting.

number of characteristics, not one of which is absolutely definite, but which, when used together, nearly always lead to a correct determination.

There is a difference already between the eggs, those of the salmon being bigger than those of the trout. As a rule salmon eggs are 5—7 mm. in diameter and have a decided red colour, while eggs of sea-trout are 5—6 mm. or a little more, (eggs of brook-trout are from 4—5 mm. upwards) and less red even quite pale. There is no systematic difference in the colour, which depends on the nourishment of the mother fish; eggs of pond-salmon are pale. However, the average size of salmon eggs seems to be consistently bigger, eggs of a pond-salmon, for instance, measuring 6·1—7·1 mm.

Correspondingly, the recently hatched fry of salmon are of course mostly bigger than those of trout, and the colour of the yolk-sac will correspond to the colour of the egg. It is said to be possible to distinguish the fry of the two species by the shape of the yolk-sac; in salmon fry after a few days from hatching the yolk-sac is said to lengthen very much, its point often bending somewhat downwards; in the fry of sea-trout, the yolk-sac tapers after some days but shows no downward bend of its hinder part. Both in salmon and sea-trout this characteristic shape is said to remain for some time: in salmon for some days, in sea-trout for some weeks. At any rate this is no distinct and reliable characteristic of every individual, but it is probably applicable in practice to the fry of the two species in hatcheries where thousands of them are kept in separate hatching boxes. The value of this characteristic is hardly proved as yet; it was given by Otto Schindler ("Beiträge zur Unterscheidung der Brut forellenartiger Fische". Allgem. Fischerei-Zeitung 1933, No. 11), from whose paper the present Figures 1 and 2 are reproduced (c.f. also Fig. 3). Some minute differences, also between sea-, lake- and brook-trout, given by Schindler are hardly of value in practice.

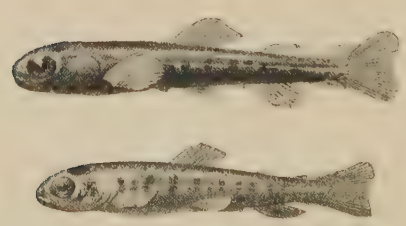


Fig. 4. Salmon fry 25·5 mm. The yolk-sac has just been absorbed. 2 × magn. (Top). — Trout fry, 22·5 mm. The yolk-sac has been absorbed some time ago. 2 × magn. (Bottom). From Johansen & Løfting.

It is of special importance to be able to distinguish between salmon and trout of the size at which they are to be transplanted, that is to say, when the fry are no longer

lying on their sides but have risen to a vertical position, which takes place some time before the disappearance of the yolk-sac. Here we have good criteria for distinction; the pectoral fins of the salmon are much bigger than those of the trout. Moreover, the salmon has a number of big and distinct spots on its back; the corresponding spots appear later in the trout and are not so big or so deeply coloured. Of course, the salmon fry are mostly bigger than the trout fry.

Fig. 5. Salmon parr, 40 mm., 1·5 × magn. (Top). — Trout, 40 mm., 1·5 × magn. (Bottom). From Johansen & Løfting.

After the hatchery stage, which corresponds to the bottom stage in nature, follows the stage at which the young salmon and trout live in the streams before they migrate to the sea at an age usually of two (one—three) years. From this are excluded lake-trout, which migrate to lakes, and brook-trout, which remain in the streams. It is to be noted that the characteristics mentioned below serve to distinguish sea-, lake-, and brook-trout from salmon, but in most cases it is the sea-trout which is mistaken for salmon.

Young salmon and trout are sometimes caught while they are in the streams; they are very much alike, but can be distinguished from each other. Growing salmon and trout are compared in Figures 4, 5, and 6, from A. C. Johansen & J. Chr. Løfting "Om Fiskebestanden og Fiskeriet i Gudenaaens nedre Løb og Randers Fjord" ("On the Fishes and fisheries in the Gudenaa and Randers Fjord [Jutland]"), Copenhagen 1919.

These show young fish of 4 and 7 cm. that have recently consumed their yolk-sac. Most of the characteristics mentioned in the following key, including not only conditions of shape and size, but also colour and behaviour of the fish, are visible in these figures. In addition reproductions of coloured

Fig. 6. Salmon parr, 72 mm. Natural size. (Top). — Trout, 72 mm. Natural size. (Bottom). From Johansen & Løfting.

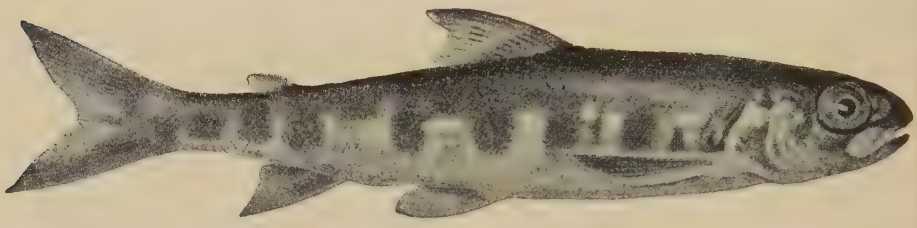


Fig 7. Salmon smolt, 11·9 cm. Natural size. From Knut Dahl.

prints are taken from a pamphlet issued by the Fishery Bureau of the Swedish Ministry of Agriculture (G u n n a r A l m. "Laxen, en värdefull naturtillgång"). Figures 7 and 8 alsó give an excellent picture of most of the characteristics mentioned below.

I. Key for determination of salmon and sea-trout before migration.

1.	Fish is comparatively slender and fusiform	Salmon
	Fish is somewhat deeper in body when seen from the side; from above, more compressed	Trout
2.	Head is more slender	Salmon
	Head is deeper and more plump	Trout
3.	When seen from above the front part of the head is shorter and more pointed	Salmon
	When seen from above the front part of the head is broader	Trout
4.	Maxilla mostly fails to reach the vertical from the hind edge of the pupil	Salmon
	Maxilla mostly reaches behind the vertical from the hind edge of the pupil	Trout
5.	Caudal peduncle is comparatively slender	Salmon
	„ „ „ „ thick	Trout
6.	All fins (except adipose fin) relatively large	Salmon
	„ „ „ „ „ small	Trout
7.	When folded backwards the points of the pectoral fins mostly reach or even pass the vertical from the front edge of the dorsal fin	Salmon
	When folded backwards the points of the pectoral fins do not reach the front edge of the dorsal fin	Trout
8.	Lobes of the caudal fin gradually grow longer and more pointed	Salmon
	Fork of the caudal fin is not so deep and its lobes are not so pointed as they gradually become in the salmon	Trout
9.	Sides mostly marked with 8—10 distinct bars (like marks from fingers smeared with bluish-grey paint)	Salmon
	Sides have no such big and distinct bars	Trout
10.	Operculum with 1—3 big black spots	Salmon
	„ „ 3—5 somewhat smaller black spots	Trout
11.	Red spots on the sides are few in number, small, and without borders. There is one in each interval between the big bluish-grey bars.	Salmon
	The sides have numerous red spots, often surrounded by light rings	Trout
12.	Adipose fin is mostly greyish-green all over	Salmon
	„ „ „ partially yellowish-red	Trout
13.	When placed on dry land the fish will rise on its belly and support itself on its big pectoral fins	Salmon
	When placed on dry land the fish will mostly continue to wriggle on its side	Trout

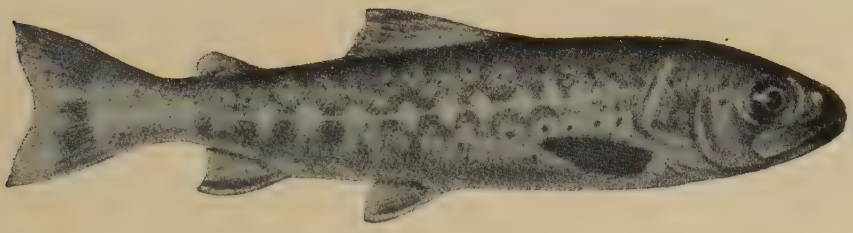


Fig. 8. Sea-trout smolt, 11·0 cm. Natural size. From Knut Dahl.

When the young salmon and sea-trout migrate to the sea, they have in most cases already grown silvery, but the colours of the young fish appear more or less distinct, at any rate when the light strikes them at a certain angle. The silvery colour of the young salmon is generally more pronounced than that of the trout; it has a nacreous sheen while the silvery colour of the trout may have a yellowish or copper-coloured tinge. The size of young salmon on migration ranges between 13 and 18 cm.; that of trout, between 10 and 20 cm.

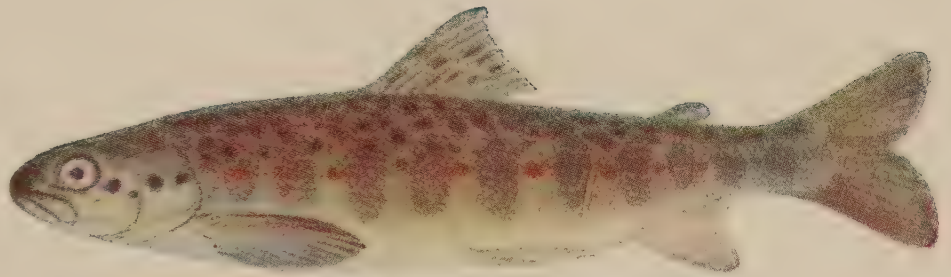
Fig. 9. Gill of salmon. From Johansen & Løfting.

Fig. 10. Gill of trout. From Johansen & Løfting.

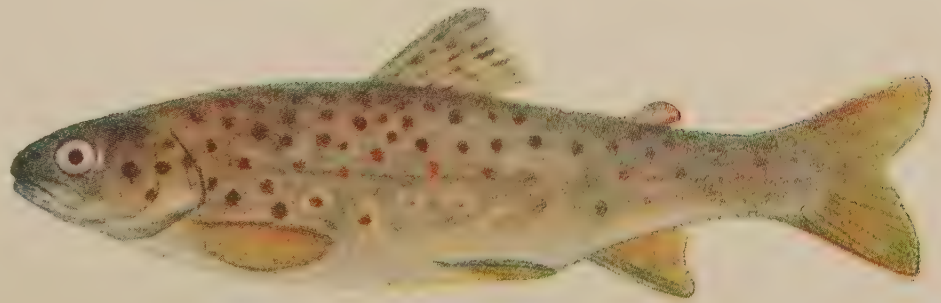
This is not the place to describe the whole life of the salmon and sea-trout, their period of life in the sea, ascent, spawning, and possible descent for another period in the sea. The purpose is to enumerate the characteristics that may be used to distinguish the two species. Whether they be silvery or coloured it will be possible in nearly all cases after the first migration to distinguish salmon from trout by means of the following characteristics.

II. Key for determination of salmon and sea-trout after the first migration.

1. More slender and fusiform (Figs. 13, 19, 22) ..... Salmon
   Deeper in body (Figs. 14, 17, 21) ..... Trout
2. Short maxilla, rarely reaching vertical from hinder edge of pupil (Figs. 13, 22, but not 19) ..... Salmon
   Longer maxilla, often reaching behind vertical from hinder edge of pupil (Figs. 14, 17) ..... Trout
3. Caudal peduncle more slender (Fig. 13; Fig.16: C : D is the greater).. Salmon
   Caudal peduncle is thicker (Fig. 14; Fig. 16: C : D is the smaller) .... Trout
4. Caudal fin often with a relatively deep fork and more pointed lobes (particularly in mielnica and grilse) (Figs. 13, 22); in older individuals often no fork (Fig. 20) ..... Salmon
   Smaller fork in the caudal fin (Fig. 21), often no fork (Figs. 14, 17) Trout
5. Scales are comparatively big. On an oblique line between the adipose fin and the lateral line (including the perforated scale) there are only 11—15, mostly 13—14, scales (Fig. 16) ..... Salmon
   Scales are smaller. On the above-mentioned oblique line there are 14—19, mostly 16, scales ..... Trout
6. In contrast to the young fish before migration, older salmon have smaller fins than trout of corresponding size. The depth of the anal fin (Fig. 16 B) is fairly small (Fig. 13) as compared with the length of the caudal peduncle (Fig. 16 C). ..... Salmon
   Bigger fins. Depth of the anal fin greater in comparison to the length of the caudal peduncle (Fig. 14) ..... Trout
7. Gill-rakers on the first gill-arch are all staff-like, also the upper and and lower ones (Fig. 9) ..... Salmon
   Gill-rakers on the first gill-arch are staff-like in the middle, but the upper and lower ones are only like small knobs (Fig. 10) ..... Trout
8. Vomer (in the front of the palate) is anteriorly ovate or pentagonal and without teeth; the long hinder part, however, which has a low longitudinal ridge, carries teeth; there are mostly 2—3 teeth on a transverse line in front, and behind it 1—4 teeth along the middle (the teeth fall out in old fish); behind the front teeth there is a slight narrowing of the vomer (Fig. 15) ..... Salmon
   Vomer is long. Its front part is triangular and mostly carries on a transverse row 3—4 teeth posteriorly; its long hinder part has a longitudinal ridge and mostly carries 1—6 teeth, most of which are lost with advancing age. The vomer is broadest behind the front teeth and narrows behind these (Fig. 15) ..... Trout
9. On the operculum of silvery fish there are few or no spots (Figs. 13, 22) Salmon
   On the operculum of silvery fish there are mostly several black spots (Figs. 14, 17) ..... Trout
10. On the sides of the body and tail of silvery fish black spots are scanty; posteriorly below the lateral line they are found only in fish that have already spawned (Figs. 13, 22) ..... Salmon
    On the sides of the body and tail of silvery fish black spots are mostly numerous; also posteriorly some are often found below the lateral line, though the number of black spots may be comparatively small, particularly in young silvery fish (Figs. 14, 17) ..... Trout
11. Edges and points of the pectoral fins of silvery fish are greyish-black or bluish-black (Fig. 13) ..... Salmon
    Pectoral fins of silvery fish are lighter (Fig. 14) ..... Trout
12. Caudal peduncle tapers and is well marked off from the base of the caudal fin (Figs. 13, 19, 22) ..... Salmon
    Caudal peduncle has a more uniform depth and passes more smoothly into the base of the caudal fin (Figs. 14, 17) ..... Trout



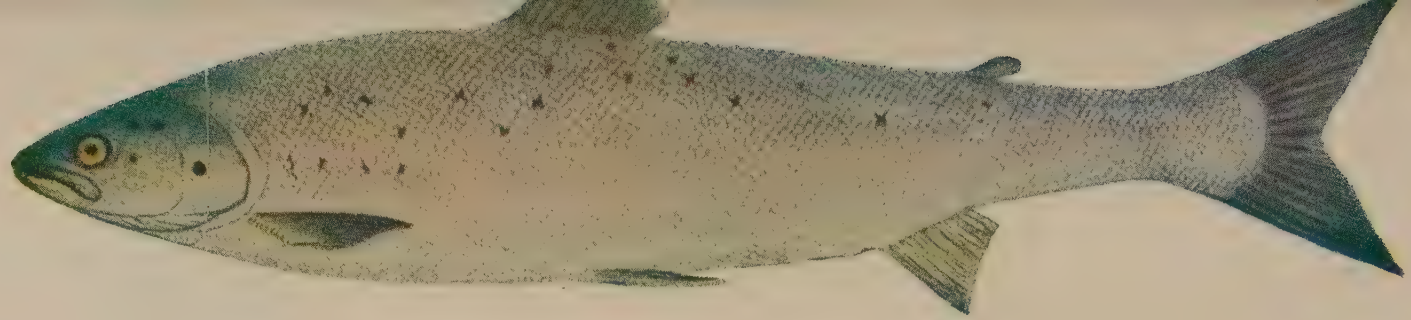
11.



12.

11) Salmon Parr, 15 cm.

12) Sea-Trout, 14 cm.



13.

14.

13) Salmon in second summer of sea life – Grilse, 46 cm.

14) Sea-Trout in second summer of sea life, 45 cm.

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Drawn and coloured by G. Swenander.

13. Adipose fin is often situated behind the posterior end of the root of the anal fin (Fig. 13) ..... Salmon
Adipose fin is mostly situated above the anal fin (Fig. 14, but not 17) Trout
14. Dorsal fin of silvery fish has no spots or only at its root (Fig. 13) .... Salmon
Dorsal fin of the silvery fish has numerous spots (Figs. 14, 17) ..... Trout

Observation of characteristic No. 8 (the vomer) would entail injury to fish, which one would try to avoid with a valuable fish. The remainder can be observed without injuring the fish. It need hardly be emphasized that one characteristic alone should not be relied upon; all of them should be examined if possible or at any rate the most important, viz., Nos. 1, 2, 3, 5, 6, and particularly No. 7; that is to say shape, maxilla, caudal peduncle, size of scales, size of anal fin, and gill-rakers. The latter seems to be the most reliable of all characteristics and is not difficult to use because, when the fish is not too small, it is easy to obtain a clear view of the gill-rakers when the operculum is raised.

The importance of being able to distinguish salmon from trout lies, among other things, in the fact that this is the only way in which it is possible to decide whether the salmon stock is increasing or decreasing and whether transplantations of salmon fry yield positive results. Reliable criteria for distinguishing the two species are of special value when

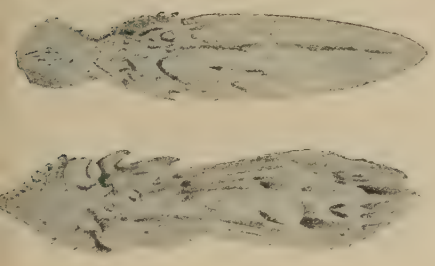

Fig. 15. Vomer of salmon (Top) and trout (Bottom).
From Zoologia Danica.

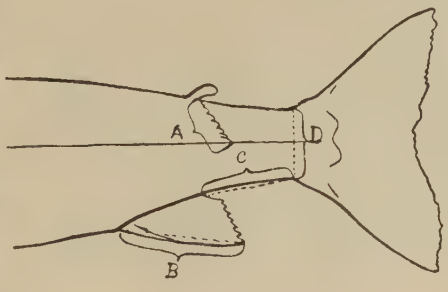

Fig. 16. Method of measuring.
From Knut Dahl.

Fig. 17. Ascending trout, male, 57·5 cm. From Johansen & Løfting.

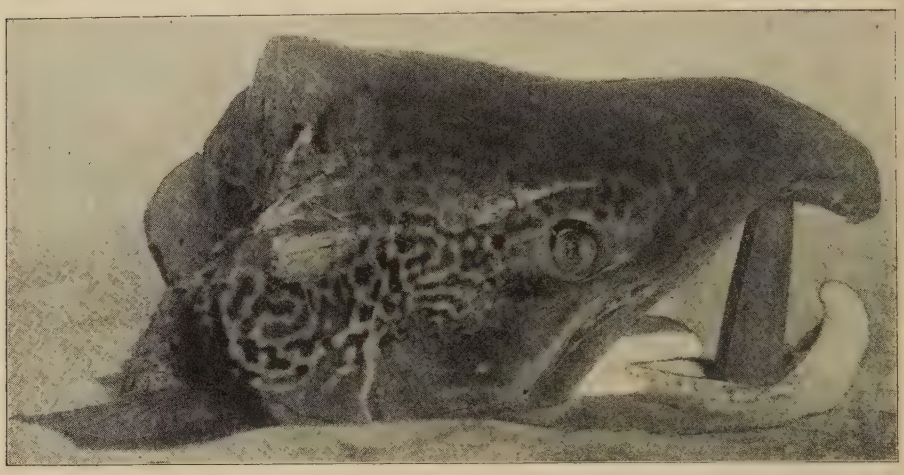

Fig. 18. Coloured male salmon, 22 kg., the head. Ferskvandsfiskeribladet 1932, p. 153.

it is desired to introduce size-limits. It is then important that the fisherman should immediately be able to see whether the fish may be landed or must be released as should be done at once in order to avoid injury to the fish. For such a purpose it would be advisable to rely mainly on one external characteristic, and the best of them is possibly the number of spots on the operculum. Though some mistakes may undoubtedly be expected to result from using this characteristic alone the diagnosis would probably be correct in a sufficient number of cases to give a satisfactory result in practice. In accordance with resolutions passed in Stockholm in August 1946 by the Salmon and Trout Committee of the International Council for the Exploration of the Sea, this question is now under discussion in a number of countries.

Fig. 21. Trout kelt, female, 62·1 cm., 1·5 kg. From Henking.

Fig. 19. Silvery salmon, female, 96 cm., 10 kg. Ferskvandsfiskeribladet 1933, p. 107.

Fig. 20. Salmon kelt, male, 17·5 kg. Ferskvandsfiskeribladet 1933, p. 106.

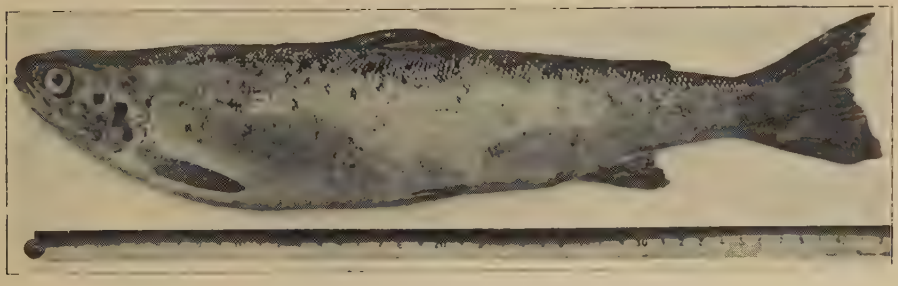

Fig. 22. Silvery pond-salmon, female, 42 cm., 725 g. Ferskvandsfiskeribladet 1932, p. 150.

Note on the Council's Hydrographical Card-Index.

By

Jens Smed.

THE card-index, which was started by Captain W. Nellemose records observations of temperature and salinity, taken simultaneously. The region covered comprises the North Atlantic, the Norwegian Sea, the North Sea, the Transition Area, and the Baltic.

Two sorts of cards are employed: "surface cards", for surface observations only; and "station cards", for observations at a series of depths at stations. The surface observations at stations are recorded both on the station cards and on the surface cards. Both sets of cards record the following data: — year, date, position, temperature and salinity. The station cards also indicate the depths to which the recorded temperatures and salinities relate, and the bottom depth. In addition the cards carry reference numbers or symbols indicating the publications from which the observations were taken. The cards are arranged by 1°-squares.

The card-index contains all temperature and salinity observations published in the *Bulletin Hydrographique* 1902—1939. Numerous other publications have been searched and the relevant observations extracted and recorded on the cards. The card-index may undoubtedly be considered as containing most of the available data on salinity (with simultaneous observations of temperature) for the above-mentioned waters.

Copies — manuscript or Leicafilm — of index-cards may be had upon application to the Hydrographical Department of the Council, Charlottenlund Slot, Charlottenlund. If copies of a large number of index-cards are desired, it may be necessary to make a moderate charge, to cover the cost of copying.

Current Bibliography.

Prepared by the Editor.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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